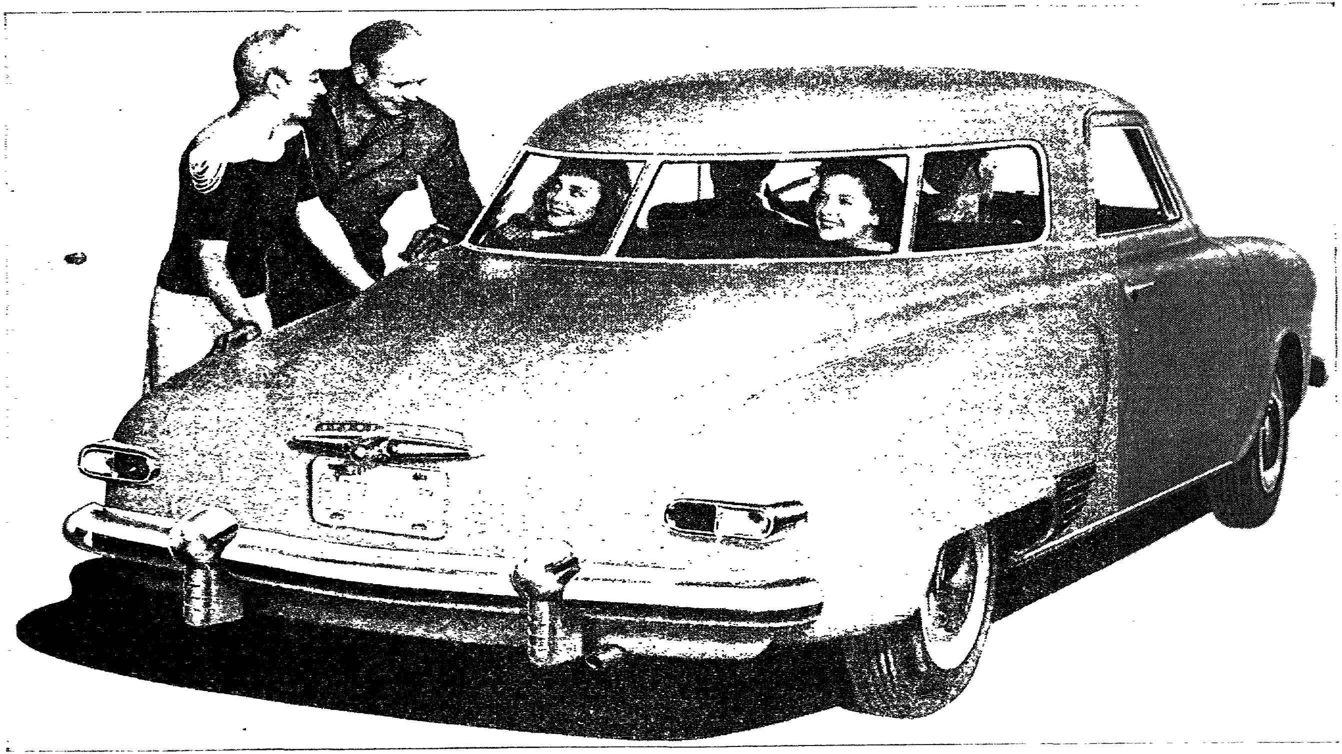


REAR VIEW OF 1947 STUDEBAKER FIVE-PASSENGER CHAMPION COUPE
Courtesy of the Studebaker Corporation

SERIES PUBLICATION

AUTOMOBILE ENGINEERING

A HOME-STUDY COURSE AND GENERAL REFERENCE WORK *on the* Construction, Care, and Repair of Cars and Trucks; on Ignition and Starting Systems; also Instructions on Diesel Engines; Service Station Operation

Prepared by a Staff
of Automobile Experts
Under the Supervision of
RAY F. KUNS
Formerly Principal, Central Vocational High School, Cincinnati Public School; Member of Society of Automotive Engineers, American Vocational Association, National Education Association

OVER FIFTEEN HUNDRED ILLUSTRATIONS • FOUR VOLUMES

VOLUME 2

AMERICAN TECHNICAL SOCIETY
CHICAGO, U.S.A.
1948

Reprinted 1944
Reprinted 1945
Reprinted 1946
Reprinted 1947

Printed in the U.S.A.

Authors and Collaborators

RAY F. KUNS

Formerly: Principal, Central Vocational High School, Cincinnati; Supervisor, National Defense Classes in General Auto Mechanics; Classes in Engine Tune-up and Dynamometer Testing; Technical Editor, *Automobile Digest*. Member: Society of Automotive Engineers, American Vocational Association, and National Education Association

CHARLES B. HAYWARD

Consulting Engineer

Formerly President and General Manager, The Stirling Press, New York City

Member, The Aeronautical Society

✧

L. H. MORRISON, B.S. in M.E.

Late Consulting Engineer

Formerly: Editor, *Diesel Power;* Member, American Society of Mechanical Engineers

Author, "High-Speed Diesel Engines"

MORRIS A. HALL, B.S.

Mechanical Engineer and Editor

Author, "What Every Automobile Owner Should Know"

TOM C. PLUMRIDGE

Head, Automobile Engineering and Mechanical Departments, American School

Formerly Instructor, U.S. Aviation Mechanics Training School, St. Paul, Minnesota

Associate Member, Society of Automotive Engineers

Consulting Engineer, American Technical Society

✧

FRANK C. MOCK

Director of Engineering and Sales, Aircraft Carburetor Section, Bendix Products Division, Bendix Aviation Corporation, South Bend, Indiana

Member, Society of Automotive Engineers

Authors and Collaborators—*Continued*

F. R. DeFOREST, B.S.

Instructor, Automotive Design and Repair, Texas A. and M. College
Instructor in Charge of Engine Testing Laboratory, Automotive Vocational High School, Cincinnati, Ohio
Formerly Assistant Professor, Automotive Engineering, Mississippi A. and M. College
Author, "Auto Trucks and Tractor Laboratory Manual"

JAMES McKINNEY

President, American School
Executive Vice-President, American Technical Society
Formerly Assistant Professor, Vocational Education, University of Illinois

K. C. SMITH

Instructor, Aircraft Engines, Automotive Vocational High School, Cincinnati, Ohio
Co-ordinator, Radial Aircraft Engine Assembly and Testing for National Defense
Formerly Chief Tester, Experimental Laboratory, Le Bond Aircraft Engine Corporation, Cincinnati, Ohio
Formerly Flight Mechanic, Royal Air Forces
Formerly Diesel Engine Operator, Mexico and Cuba
Author, "Marine Engines"

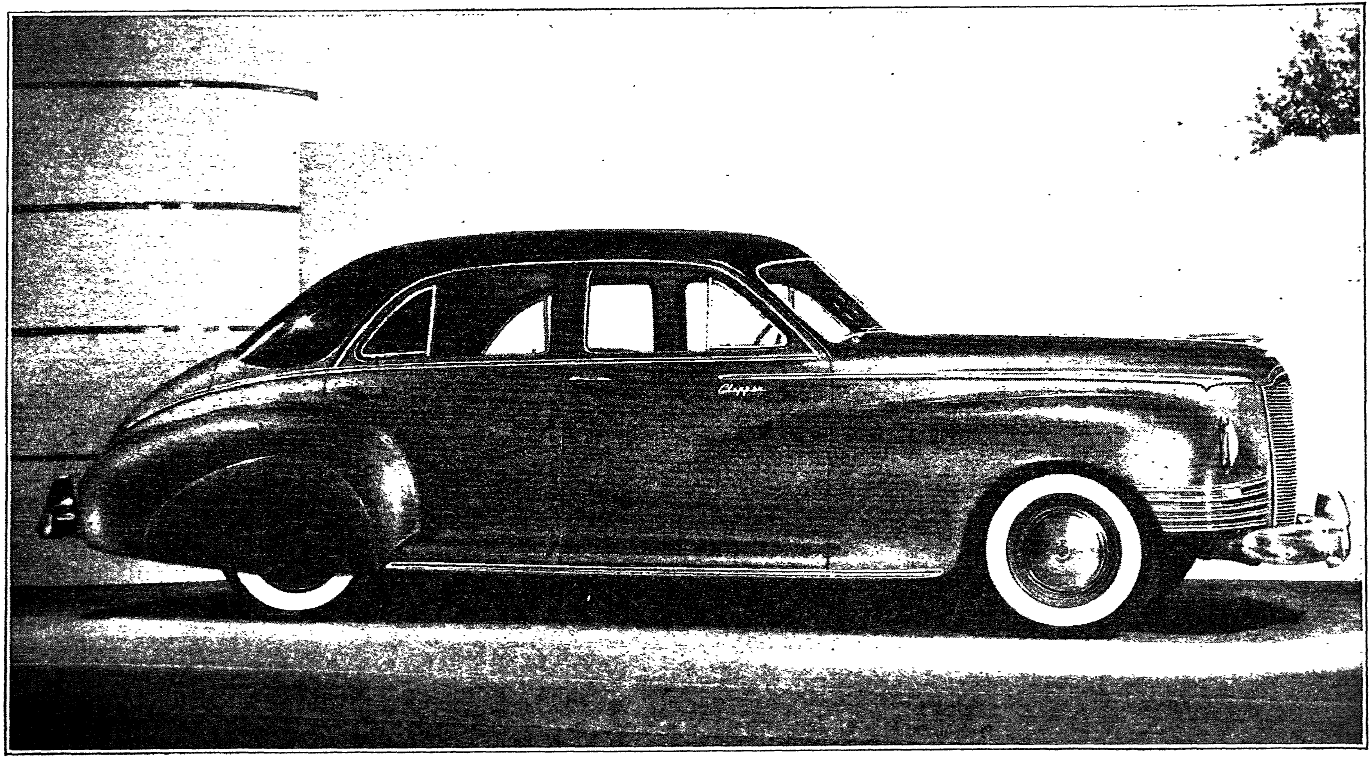
THOMAS A. O'CONNOR

Assistant to the Vice-President, Studebaker Pacific Corporation, Los Angeles, California
Associate Member, Society of Automotive Engineers

Acknowledgments

GRATEFUL acknowledgment is here made also for the invaluable cooperation of the foremost Automobile Firms and Manufacturers, listed below, in making these volumes thoroughly representative of the very latest and best practice in the construction, operation, and repair of Automobiles, Aviation Engines, etc.; also for the valuable drawings, data, illustrations, suggestions, criticisms, and other courtesies.

Aeronautical Corporation of America, Middletown, Ohio; Allen Electric & Equipment Co., Kalamazoo, Mich.; The Buda Co., Harvey, Ill.; Buick Motor Div., General Motors Corp., Flint, Mich.; Bendix Products Corp., South Bend, Ind.; Ed. G. Budd Mfg. Co., Philadelphia, Pa.; Chevrolet Motor Div., General Motors Corp., Detroit, Mich.; Cadillac Motor Car Div., General Motors Corp., Detroit, Mich.; Continental Motors Corp., Detroit, Mich.; Chrysler Corporation, Chrysler, Dodge, DeSoto and Plymouth Sales Divisions, Detroit, Mich.; Crosley Corporation, Cincinnati, Ohio; Carter Carburetor Corporation, St. Louis, Mo.; Douglas Aircraft Co., Inc., Santa Monica, Calif.; Delco-Remy Div., General Motors Corp., Anderson, Ind.; Diesel Engine Division, General Motors Corp., Cleveland, Ohio; Evinrude Motors, Milwaukee, Wis.; Ford Motor Co., Dearborn, Mich.; Firestone Tire & Rubber Co., Akron, Ohio; B. F. Goodrich Co., Akron, Ohio; Graham-Paige Motors, Inc., Detroit, Mich.; Harley-Davidson Motor Co., Milwaukee, Wis.; Hall Mfg. Co., Toledo, Ohio.; Hudson Motor Car Co., Detroit, Mich.; Hercules Motors Corp., Canton, Ohio; International Harvester Co., Inc., Chicago, Ill.; Lee Tire & Rubber Co., N. Y., N. Y.; Mallory Electric Corp., Detroit, Mich.; Nash Motors Div., Nash-Kelvinator Corp., Kenosha, Wis.; Olds Motor Works Div., General Motors Corp., Lansing, Mich.; Packard Motor Car Co., Detroit, Mich.; Philco Radio Corporation, Philadelphia, Pa.; Pontiac Motor Div., General Motors Corp., Pontiac, Mich.; Rubber Mfgrs. Association, N. Y., N. Y.; Studebaker Corporation, South Bend, Ind.; Sunnen Products Co., St. Louis, Mo.; U. S. Rubber Products Co., New York, N. Y.; The Wayne Works, Richmond, Ind.; Jos. Weidenhoff, Inc., Chicago, Ill.; Wagner Electric Corp., St. Louis, Mo.; Willys-Overland Motors, Inc., Toledo, Ohio; Yellow Truck & Coach Mfg. Co., Pontiac, Mich.; Zenith Carburetor Div., Bendix Aviation Corp., Detroit, Mich.



1942 PACKARD "CLIPPER"
Courtesy of Packard Motor Car Company

FOREWORD

ALTHOUGH recorded history is not wholly agreed as to the first man in America to perfect and operate an automobile, this honor is generally accorded to Charles E. Duryea of Springfield, Massachusetts, who on September 12, 1892, operated a Duryea gasoline automobile in that city. By the year 1900, a number of "gasoline buggies" were in process of manufacture and by 1910 automobile building in the United States had begun to assume serious proportions. Quantity production methods have resulted in the building of over fifty-five million passenger cars and almost four million trucks.

As a result of the highly developed skill of automobile production, the call for old-fashioned *repair service* is gradually being displaced by a call for a new type of man trained in *maintenance service.*

Perhaps the first line of defense, so to speak, against the needs of the modern motor car is the list of three hundred and twenty-five thousand gasoline service stations offering maintenance service in varying degrees. Next in point of number comes sixty-five thousand general repair garages and then some thirty-five thousand car dealers. The men required to man all of these stations require specialized training.

Specialized equipment has been developed, designed to help the garage men diagnose motor car troubles. It is a matter of record that the scientific equipment is more accurate than the human element and the up-to-date stations are requiring men who can handle this type of equipment.

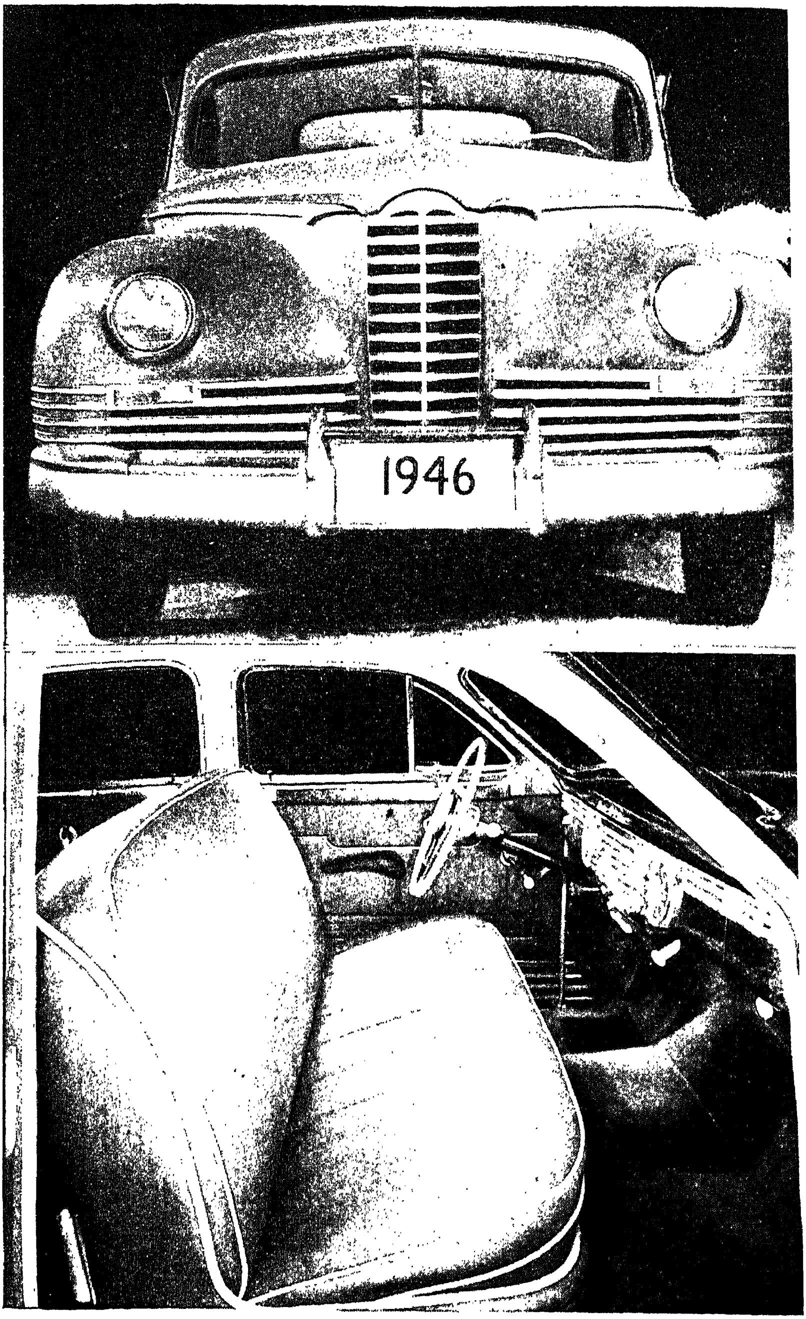
There is no need to guess the type of lubricant required by any part of the automobile, nor is there any need to make an estimate or guess as to the exact amount of clearance to be allowed at any one point in the adjustment of the intricate automotive assemblage. Accurate information is provided in the way of lubrication charts, wiring diagrams and data sheets.

Service men have taken it upon themselves to attempt to make the automobile fool-proof and to make it a safer vehicle to go upon the highways. This has resulted in safety campaigns in the servicing of brakes, headlights, and the third vital item, front axle and steering geometry.

Although the principle of the Diesel or oil engine is practically as old as that of the gasoline engine, which has been developed on the

Table of Contents

TABLE OF CONTENTS



FRONT AND INTERIOR VIEWS OF 1946 PACKARD "CLIPPER"
Courtesy of Packard Motor Car Company

INTERNAL COMBUSTION ENGINES

ELEMENTARY PRINCIPLES

General Description. The term internal combustion motor generally refers primarily to gasoline engines such as are used on air craft, automobiles, motorcycles, motorboats, and small stationary installations. The force which develops the power is derived from the explosion of a gaseous charge consisting of a mixture of gasoline vapor, and air.

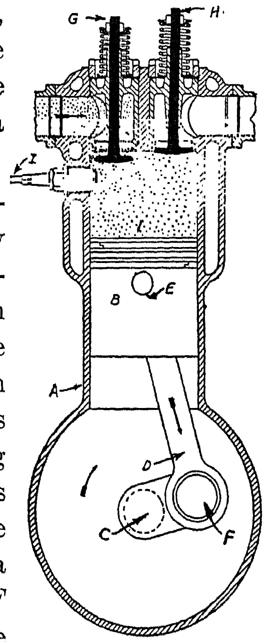


Fig. 1. Simple Engine (Intake Stroke)

The simplest type of engine, Fig. 1, consists of a cylinder *A* in which there is a hollow piston *B* (free to slide up and down), a crankshaft *C*, and a rod *D*, connecting the piston through the piston pin *E* to the crank on the shaft. As the piston moves up and down in the cylinder, this reciprocating motion is converted by the operation of the connecting rod on the crank *F* into a rotary motion, as shown by the arrow near *C*. The whole action may be compared to that of a boy on a bicycle, *D* representing the boy's leg and *F* the pedal. At the head of the cylinder are shown two valves, *G* and *H*, and a spark plug *I*, whose functions are to admit the charge, explode it, and permit it to escape, by which operations and their repetition the reciprocating motion of the piston is set up and maintained. The successive explosions of the charges produce considerable heat. The cylinder *A* is usually surrounded by a jacket and water is circulated around in the space, Figs. 2 and 3, between this jacket and the cylinder, thus cooling the cylinder. Another cooling method is by air, in which case the outer wall of the cylinder is constructed with fins or projections which dissipate the heat In order, there-

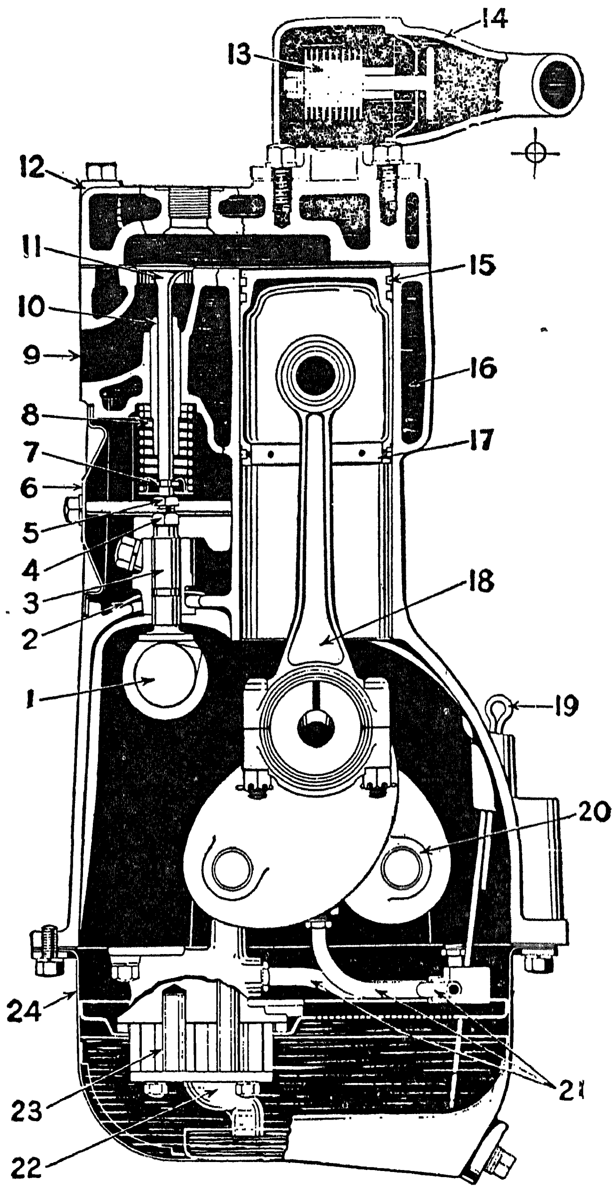


Fig. 2. End View Section of Modern Engine—The Pontiac

1—Camshaft; 2—Valve Lifter Bracket Baffle; 3—Valve Lifter; 4—Adjusting Screw Lock Nut; 5—Valve Lifter Adjusting Screw; 6—Engine Side Cover; 7—Valve Spring "U" Washer; 8—Valve Spring; 9—Valve Port; 10—Valve Guide; 11—Valve; 12—Cylinder Head; 13—Thermostat; 14—Water Manifold; 15—Piston Ring; 16—Water Jacket; 17—Piston Ring; 18—Connecting Rod; 19—Oil Level Gauge; 20—Crankshaft; 21—Oil Tubes.

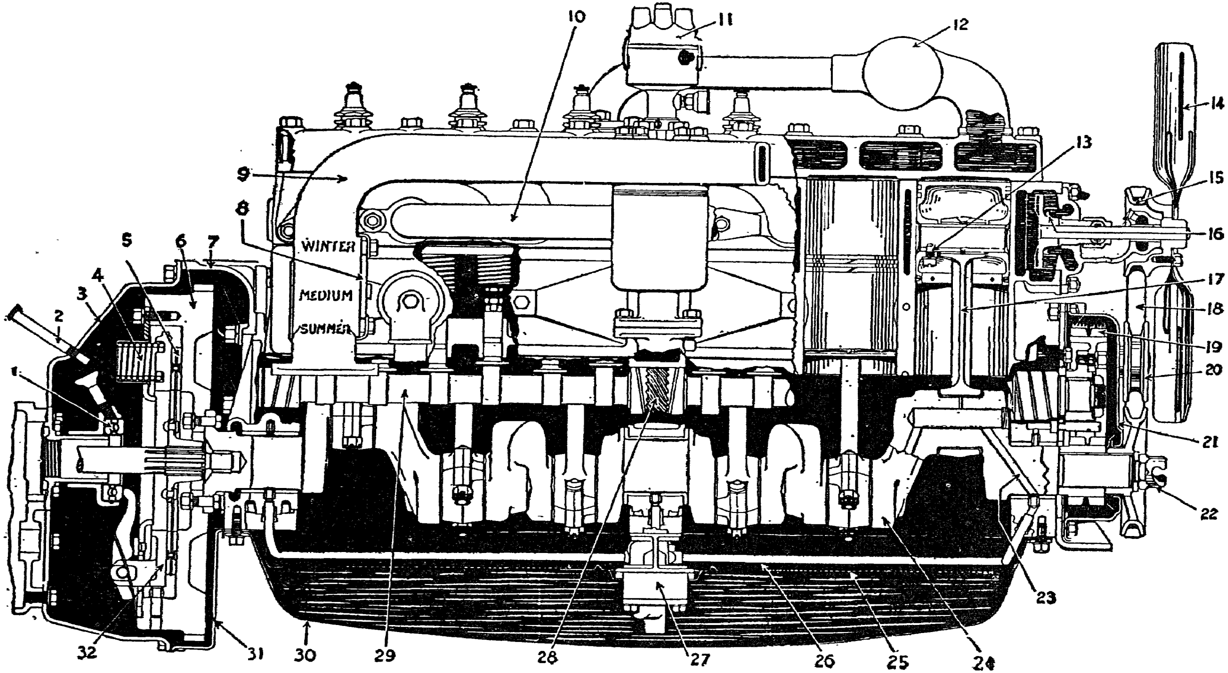


Fig. 3. Sectional Side View of Pontiac Engine and Clutch
1—Clutch Release Bearing; 2—Clutch Release Bearing Oiler; 3—Bell Housing; 4—Clutch Spring; 5—Clutch Pressure Plate; 6—Flywheel; 7—Flywheel Housing; 8—Ventilator Outlet; 9—Exhaust Manifold; 10—Intake Manifold; 11—Distributor; 12—Thermostat Housing; 13—Piston Pin Locking Screw; 14—Fan; 15—Fan Belt Pulley; 16—Water Pump; 17—Connecting Rod; 18—Fan and Generator Belt; 19—Camshaft Sprocket; 20—Generator Pulley; 21—Timing Gear Case Cover; 22—Starting Nut; 23—Oil Passage in Crankshaft; 24—Crankshaft; 25—Oil Screen; 26—Oil Pipe; 27—Oil Pump; 28—Oil Pump and Distributor Drive Gear; 29—Camshaft; 30—Oil Pan; 31—Flywheel Cover; 32—Clutch Drive Plate.

fore, to secure the above action, the following mechanical devices must be provided: (1) A cylinder containing a freely moving piston, capable of being lubricated effectively; (2) a combustion chamber in whose walls are valves for the admission and exhaust of the gas, and valve seats so arranged that the joints will remain gas-tight when desired; (3) an outside, dependable means of ignition, with sparking points inside the combustion chamber, (4) a source of fuel supply, which, in the ordinary engine, must convert liquid into a vapor; and (5) a cylinder construction which will carry off the surplus heat or allow of its being carried off.

Historical. The first workers in this field of the explosion engine were perhaps Huyghens, Hautefeuille, and Papin, who experimented with motors, using gunpowder as a fuel, in the latter part of the seventeenth century. A patent was obtained in England by John Barber, in the closing years of the eighteenth century, on a turbine using a mixture of gas or vapor and air for the fuel. A few years later Robert Street, another Englishman, built an oil engine in which the vapor was ignited by a flame at the end of the first half of the outward stroke.

From 1800 to 1854 several French and English patents were granted for internal combustion engines, most of the engines being double acting, that is, one explosion acting on one side and the next explosion acting on the other side of the piston, and some using electrical ignition. In 1858, Degrand made a big advance by compressing the mixture in the cylinder instead of in separate pumps.

The first commercially practical engine was developed about 1860 by Lenoir, who marketed in Paris a 1-horsepower, double-acting gas engine closely resembling a horizontal steam engine. This used what is now called jump-spark ignition and was made in sizes up to 12 horsepower. It gave considerable trouble in many cases, but the principal reason for its failure was the excessive amount of gas required—60 to 100 cubic feet of illuminating gas per brake-horsepower hour*—which was more than three times the consumption of a modern gas engine and prevented competition with steam.

The gas engine industry as we know it today was really started in 1861, when a young German merchant, N. A. Otto, developed an

*Brake horsepower (b. hp.) is the power delivered from the shaft of the engine. When delivered for one hour it is called a b.hp.-hour.

experimental engine in which intake, compression, power, and exhaust were accomplished in the one working cylinder. Otto failed to realize fully the great promise held out by his engine and temporarily abandoned its development.

In the year 1862 it was pointed out by a French engineer, Beau de Rochas, that in order to get high economy in a gas engine certain conditions of operation were necessary, the most important being the compression of the explosive mixture to a high pressure before ignition. In order to accomplish this, he proposed that the cycle of operations should occupy four strokes or two complete revolutions of the engine and that the operation should be as follows:

(1) Suction or admission of the mixture throughout the complete forward stroke.

(2) Compression of the mixture during the whole of the return stroke, so that it finally occupies only the clearance space between the piston and cylinder head.

(3) Ignition of the charge at the end of the second stroke and expansion of the exploded mixture throughout the whole of the next forward stroke.

(4) Exhaust beginning at the end of the forward stroke and continuing throughout the whole of the last return stroke.

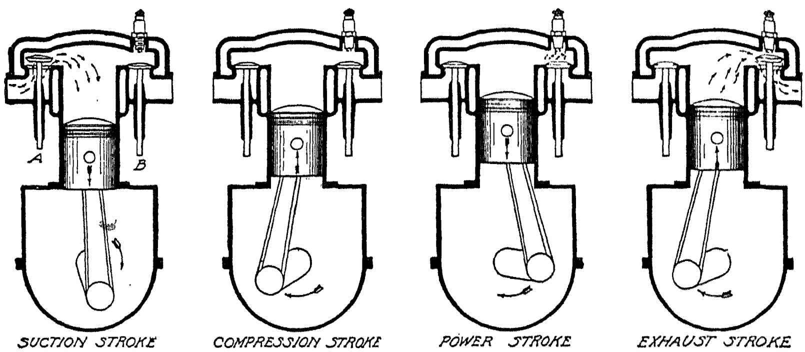
De Rochas had developed a brilliant theory but never put it into practical use. The pamphlet containing this idea remained practically unknown until about 1876, when it was discovered and published in the course of a patent lawsuit against Otto and his associates, who were using this cycle in their engine, Otto having returned to the development of his engine in 1863. Although the original idea was perhaps Beau de Rochas', the credit really belongs to Otto, who made practical use of what would otherwise have been an unknown theory. In recognition of this fact the four-stroke cycle which Otto adopted in his engine and which is used in the majority of our modern motors is generally known as the Otto cycle.

CYCLE OF EXPLOSION ENGINE

The cycle of the explosion engine, therefore, consists of four distinct steps: (1) **intake** of the charge of explosive fuel; (2) **compression** of this charge; (3) **ignition** and **burning** of this charge; and (4) **exhaust** or expulsion of the burned charge. If this complete process requires four strokes of the piston rod in any one cylinder, the motor is designated as a four-cycle motor, although it would

be more exact to call it a four-stroke cycle. If the complete process is accomplished in two strokes of the piston, the motor is designated as a two-cycle motor.

Four=Stroke Cycle. One complete operation of a single-cylinder Otto or four-cycle explosion engine is shown in Figs. 4, 5, 6, and 7. Fig. 4 shows the end of the first or suction stroke of the cycle. At the beginning of this stroke when about $\frac{1}{16}$ inch past the dead center, the inlet valve *A* is opened by a valve lifter whose movement is controlled by the cam on a secondary shaft driven through gears at half the speed of the engine. This allows the vapor supplied by the carburetor, which is an instrument for converting the liquid fuel into a vapor or gas, Fig. 8, to be drawn into the cylinder by the



Figs. 4, 5, 6, and 7. Diagrams Showing One Complete Cycle of a One-Cylinder Explosion Engine

suction produced by the downward-moving piston. During this stroke the exhaust valve *B* has remained closed.

The conditions shortly after the beginning of the second or compression stroke are shown in Fig. 5, both valves being closed. The piston, traveling as indicated by the arrows, compresses the charge to a pressure of about 60 pounds, when it is ignited at or before the end of the stroke by a spark taking place in the spark plug as shown in Fig. 6. Its arrangement is shown in detail, Fig. 9, the spark passing between the points *A* and *B*. The force of the explosion drives the piston downward as shown in Fig. 6, which represents the power stroke. During these last two strokes, namely, the compression and working strokes, both valves if correctly timed should be completely closed.

Fig. 7 illustrates the conditions existing after the piston has begun the fourth or exhaust stroke. The exhaust valve *B* has been opened slightly before the end of the third stroke, and during this fourth stroke the gases are expelled from the cylinder through the open valve as shown. At the end of this stroke, piston and valves

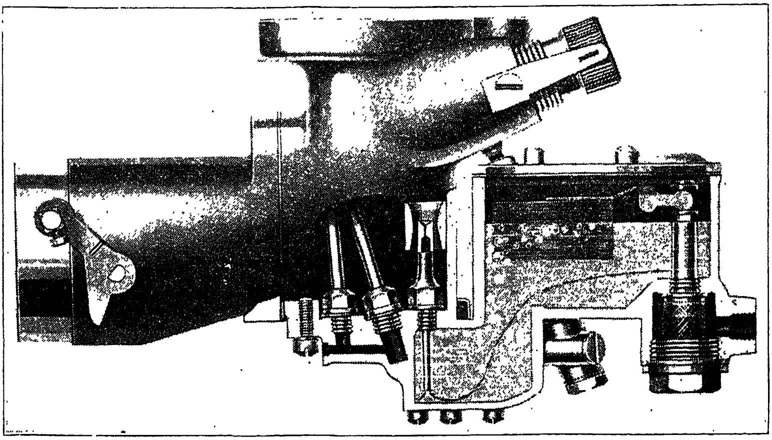


Fig. 8. Sectioned View of Up-draft Carburetor

are again brought to the proper positions for the beginning of the suction stroke, illustrated in Fig. 4.

The two strokes, suction and compression, as shown in Figs. 4 and 5, are completed in one crankshaft revolution. This may be

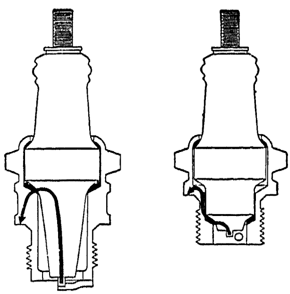


Fig. 9. Spark Plugs in Section. Black Arrows Indicate Path of Heat Flow.
Courtesy AC Spark Plug Company

termed the first revolution. The two strokes, power and exhaust, Figs. 6 and 7, are also completed in one crankshaft revolution, and this may be termed the second revolution. Therefore it takes two revolutions of the crankshaft to complete the cycle in a four-stroke cycle engine. Speaking in terms of crankshaft movement, these

two revolutions are referred to as so many degrees of crankshaft travel. A circle consists of 360 degrees and this circle, Fig. 10, is divided into four divisions of 90 degrees each. If the crank is at the point marked *A*, it will be at the zero point; if the crank is moved one-quarter of the distance around the circle, it will have moved or traveled 90 degrees; and if the rotation is continued back to the zero point, it will have moved or traveled 360 degrees. It will be seen that to complete the two revolutions necessary for the four piston strokes, the crankshaft must travel through twice this

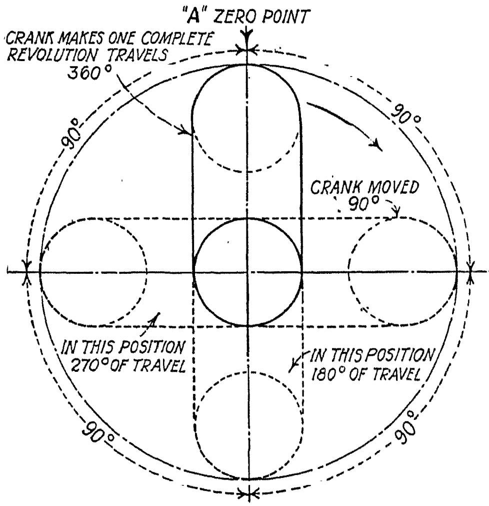


Fig. 10. Crankshaft Travel

distance, or 720 degrees. The mechanic must understand this perfectly for it is the basis of the operation of the automobile engine. The complete cycle is shown in Fig. 11.

Two-Stroke Cycle. An increased frequency of the expansion or motive stroke can be obtained by a slight modification of the Otto cycle, which results in the cycle being completed in two strokes and is consequently called the two-cycle method. Single-acting engines using the two-cycle method give an impulse every revolution, and consequently not only give a more uniform speed of rotation to the crankshaft, but also develop 60 to 80 per cent more power than four-cycle or Otto cycle engines of the same size. Moreover,

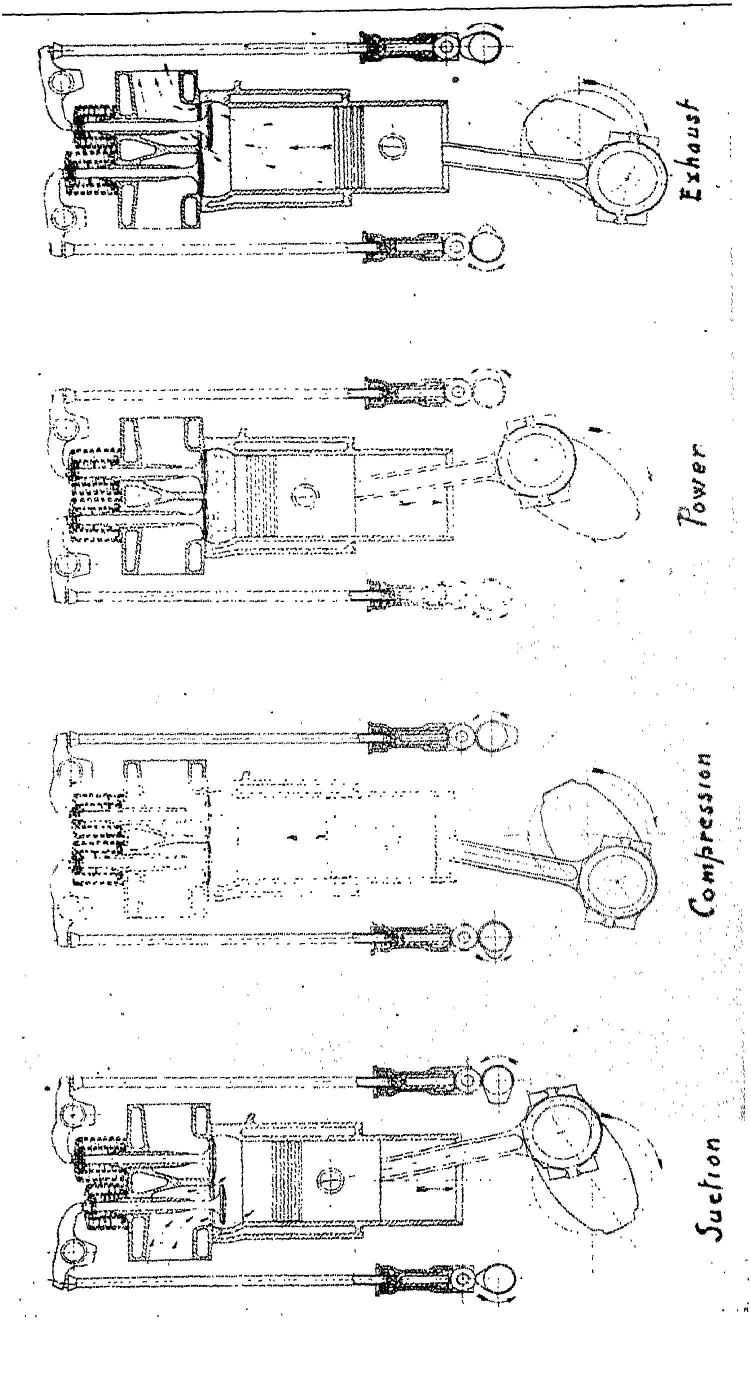


Fig. 11. Four-Stroke Cyc

they are generally of greater simplicity, having fewer valves than the four-cycle engines. An example is shown in Figs. 12 and 13 of a two-cycle engine of small size and of the two-port type; Fig. 12 is a vertical section showing the piston at the bottom of its stroke, and Fig. 13 is a vertical section in a plane at right angles to the previous section plane and showing the piston at the top of its stroke. As the trunk piston *A* makes its upward stroke, it creates a par-

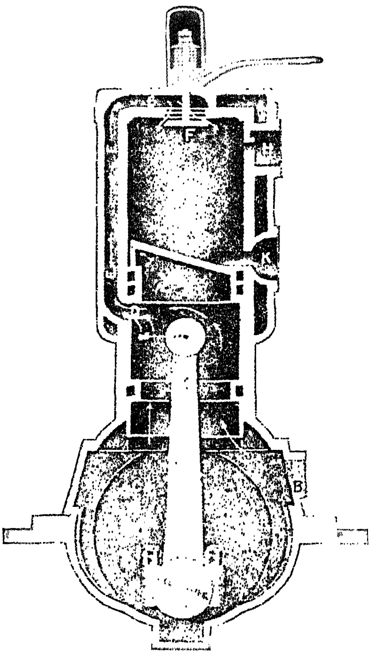


Fig. 12. Vertical Section of Two-Cycle Smalley Motor

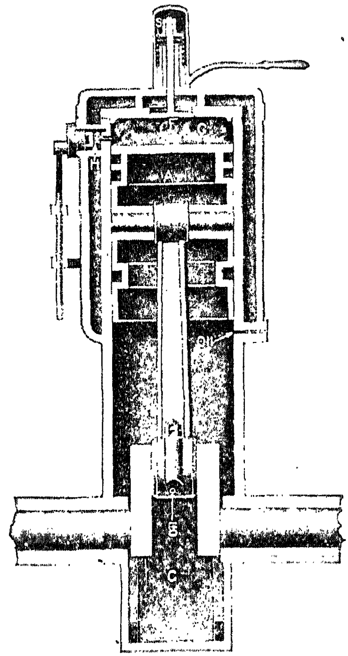


Fig. 13. Vertical Section at Right Angles to View in Fig. 8

tial vacuum below it in the closed crank chamber *C* and draws in the explosive charge through *B*. On the downward stroke, the charge below the piston is compressed to about 10 pounds pressure in the crank chamber *C*, the admission through *B* being controlled by an automatic valve (not shown) which closes when the pressure in *C* exceeds the atmospheric pressure. When the piston reaches the lower end of its stroke, it uncovers exhaust port *K* and at the same time brings admission port *D* in the piston opposite the by-

pass opening *E*, and permits the compressed charge to enter the cylinder *G* through the automatic admission-valve *F* as soon as the pressure in the cylinder falls below that of the compressed charge. The return of the piston shuts off the admission through *E*, and the exhaust through *K*, and compresses the charge into the clearance space. The charge is then exploded, Fig. 13, and the piston makes its down or motive stroke. Near the end of the down stroke, after the opening of the exhaust port *K*, the admission of the charge at the top of the cylinder sweeps the burned gases out, the complete escape being facilitated by the oblique form, Fig. 12, of the top of the piston. The motor is so designed that the piston on its return stroke covers the exhaust port *K* just in time to prevent the escape of any of the entering charge. The processes described above and below the piston are simultaneous, the up-stroke being accompanied by the admission below the piston and compression above it, while the down-stroke has expansion above the piston and a slight compression below it.

Crankshaft Determines Engine Design. We find in comparing the crankshaft movement, or travel, in the two-stroke engine that the cycle is finished in 360 degrees of crankshaft travel as against the 720 degrees in the four-stroke engine. In the four-stroke engine only one power stroke is given in every four strokes, and in the two-stroke engine every down-stroke is a power stroke.

By referring to Fig. 14 it will be found that the cranks are laid out in degrees in regard to their relation with each other. The division of the circle in degrees is used here. A crankshaft layout for a four-cylinder engine is shown at *D* and the cranks are set at 180 degrees. It will be noticed that cranks *1* and *4* are directly opposite cranks *2* and *3* and therefore are on opposite sides of the circle, or 180 degrees apart. At *E* the cranks are set at 120 degrees and are so arranged that they are one-third of the total circle distance apart. The diagram shows a six-cylinder shaft and cranks *1* and *6* move together, *2* and *5* together, and *3* and *4*. A four-cylinder engine shaft can be used in an eight-cylinder engine and a six-cylinder shaft can be used in a twelve-cylinder engine. There is a definite distance that the crankshaft travels between explosions and consequently there are a certain number of power strokes given for every revolution of the crankshaft.

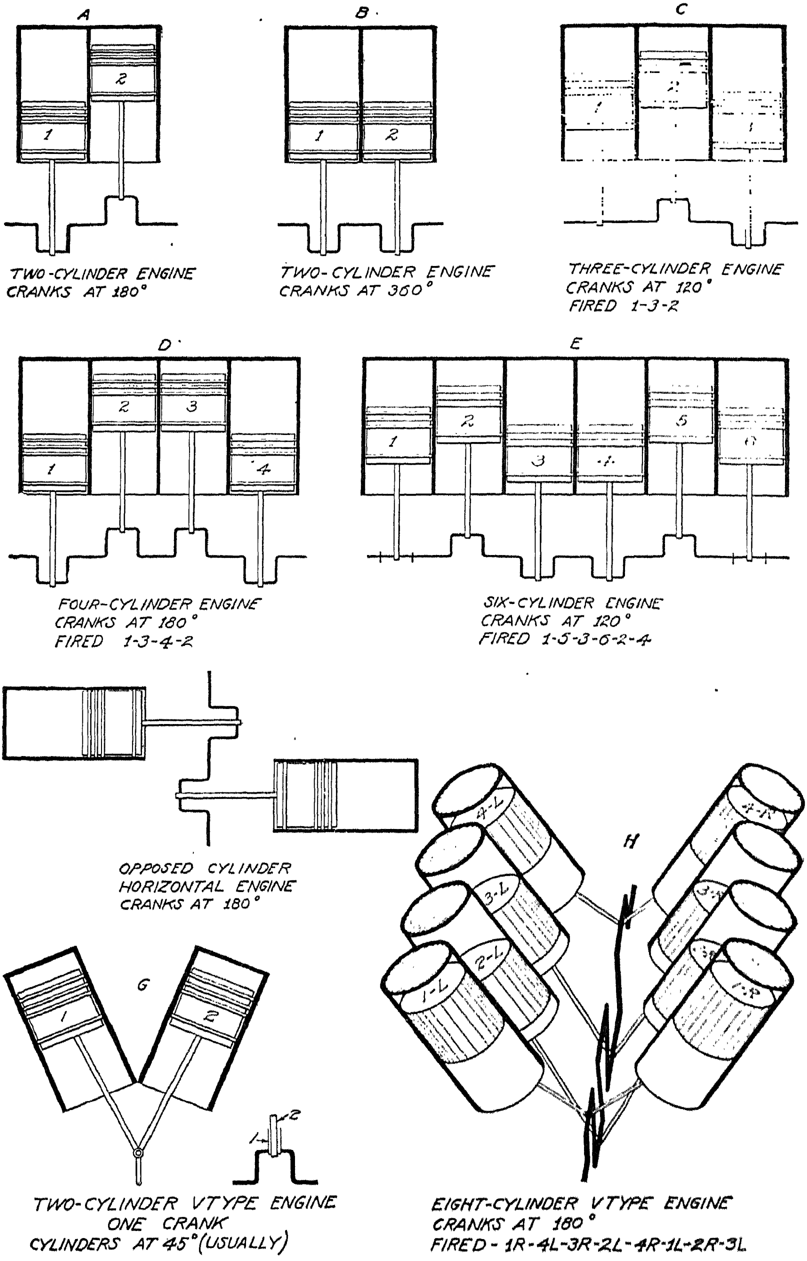


Fig. 14. Crank and Firing Arrangements for Multicylinder Four-Cycle Engines

With the cranks set at 360°, *B,* Fig. 14, we get a power stroke at each revolution. This arrangement, however, requires careful balancing to counteract the vibration which results from all parts moving in the same direction at the same time.

Four-Cylinder Engine. In the four-cylinder engine of the four-cycle type, we have two power strokes for each revolution of the crankshaft or flywheel. In order to secure smooth working, these power strokes should occur exactly one-half revolution apart. From *D,* Fig. 14, it will be seen that the four-cylinder crankshaft has two pairs of cranks just about one-half revolution apart. Pistons *1* and *4* move up, while pistons *2* and *3* move down, or *vice versa.*

Suppose, for instance, that piston *1* has just been forced down on the power stroke. Then pistons *2* and *3* will be up and *one* of these should be ready to receive the force of the explosion and should have, therefore, just compressed an explosive charge in its cylinder ready to be ignited. For the sake of illustration let us choose piston *3* to make the next power stroke. Piston *3* now moves down and pistons *1* and *4* move up. Since it is evidently impossible to have piston *1* contain an explosive charge without giving it one more up and down motion, piston *4* must make the next power stroke. This piston, therefore, moves down as a result of the explosion in cylinder *4,* and it is now necessary for piston *2* to make the next power stroke. Thus the order of firing is 1-3-4-2.

Six-Cylinder Engine. This is one of the most popular engines ever designed. It appeals to the motor-car user in that it offers a fairly even flow of power. It appeals to the mechanic in that it is not so complicated. The cost of maintenance is but slightly more than that of a four. The crankshaft, as will be noted at *E,* Fig. 14, is so arranged as to have two cranks or throws positioned at each of the 120-degree points about the circle. The six is in reality two threes, end to end, just as the straight eight is two fours, end to end. There are a number of firing orders possible for the six. One of the most popular is indicated in Fig. 14. The reader understands that the firing order is determined by the designing engineers and may not be changed by the service man. The service man is interested only in knowing the theory of design so that he may determine the firing order provided by the manufacturer.

V-Type Eight-Cylinder Engine. At one time the V engine took the country by storm and there were a large number of eights or "twin fours" on the market as well as twelves or "twin sixes." They were built in all sizes. With the exception of the Lincoln and the Cadillac, the experiment was short-lived, but later was popularized again by the Ford V-8 in the low-price field. The initial cost of an automobile is not the only consideration. The maintenance is a vital consideration.

The V-type eight in the Lincoln, Ford, and the Cadillac won a unique position for itself. This is owing to the fact that there is a minimum of space required under the hood for a very efficient

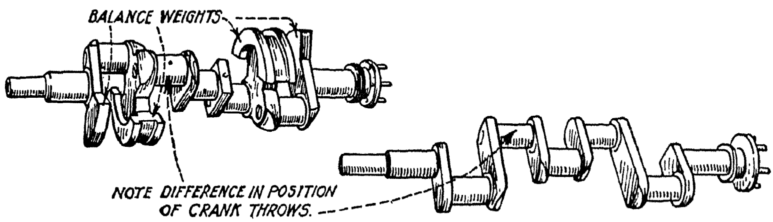


Fig. 15. View of Crankshaft
Courtesy of Cadillac Motor Company

power plant and the design of the engine is such that a high grade of performance is secured.

The four-cylinder engine was the first satisfactory power plant for automobile use. When the eight-cylinder engine was designed, it was first made in V form and the crankshaft was of the same design as the four, that is, there were four throws used. The connecting rods were set on the throws side by side, or in yoked position.

In an effort to get away from some of the vibration which the V-type engine sometimes sets up, giving a sort of "galloping" movement to the front end of the car, the Cadillac Company designed the new type of crankshaft shown in Fig. 15, at the top. This shaft has two throws set at 90 degrees advanced over the other two, instead of 180 degrees advanced, as in the case of the conventional shaft for a four or V-type eight, shown at the bottom of Fig. 15. With this arrangement the explosions still occur at the same relative positions or intervals of crankshaft travel, but a better inherent balance is secured.

Fig. 16 shows the arrangement of the pistons and the connecting rods and crankshaft throws of the Cadillac engine. The firing order for the Cadillac is 1L—4R—4L—2L—3R—3L—2R—1R. The Ford V-8 uses a shaft having the two center throws in one plane and the other two in another plane at right angles to the first.

Straight Eight-Cylinder Engine. The first design employing the eight-cylinders-in-line idea worked on the proposition that since the four-cylinder job was extremely satisfactory, as far as carburetion

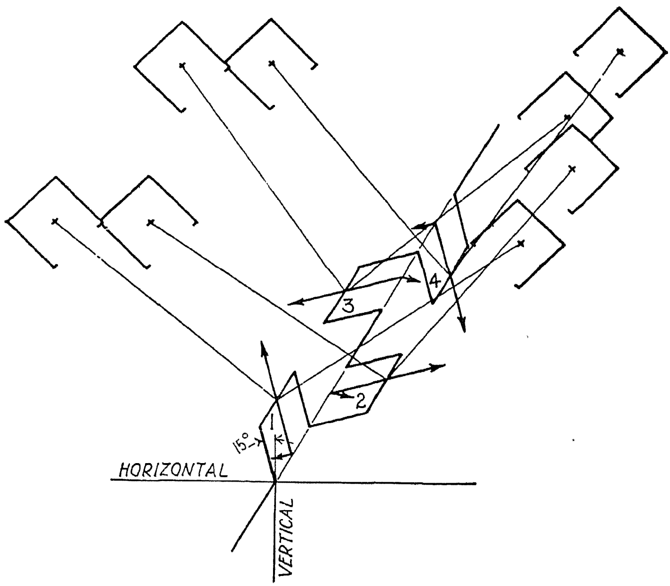


Fig. 16. Balance of New 8-Cylinder Crankshaft
Courtesy of Cadillac Motor Company

was concerned, it would be a safe principle to hold to the well-known features of the four. Accordingly the crankshaft is the same as having two four-cylinder crankshafts joined end to end but with the throws of the second, ninety degrees advanced over the first. In this way it was possible to use intake manifolds which gave approximately the same distribution of fuel charges.

When the popularity of the straight-eight engine was assured, the designers began figuring on other possible arrangements of the crankshaft throws. This resulted in the arrangement shown at *B* in

Fig. 17, where the arrangement is what is known as the 2-4-2 arrangement as contrasted to the 4-4 arrangement shown at *A*. In this arrangement it were as though one-half of a four-cylinder engine were set on each end of another four-cylinder engine. This makes possible an entirely different intake manifold arrangement. A duplex carburetor is used, one-half of which supplies cylinders 1, 2,

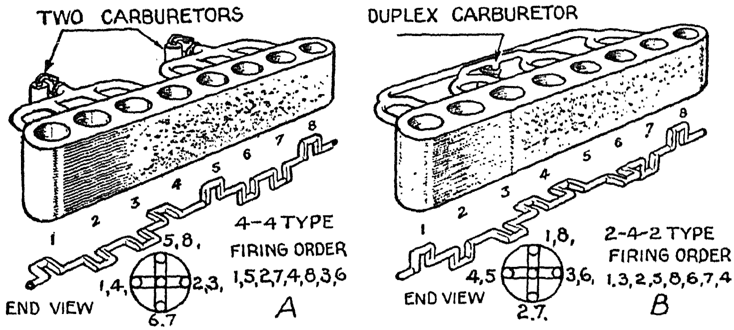


Fig. 17. The 4-4 Straight-Eight Engine Shaft Is Shown at *A* and the 2-4-2 Straight-Eight Engine Shaft Is Shown at *B*
From "The Motor," English Weekly

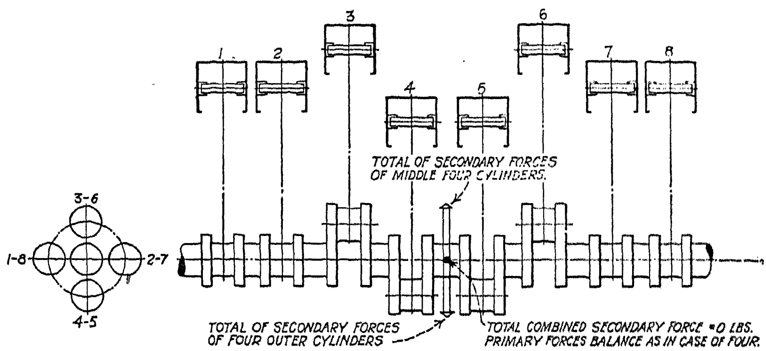


Fig. 18. View of Packard Shaft
Courtesy of Packard Motor Company

7, and 8. The other half of the carburetor supplies cylinders 3, 4, 5, and 6. It will be noted that the intake manifold length is approximately even for any cylinder supplied by either side of the carburetor. Since there is no interconnection between the two mixing chambers of the carburetor, each having its own throttle valve, equal distribution of gases is assured.

The Packard Straight-Eight displaced the Twin-Six for a time and has been well received. The crankshaft for this job appears in Fig. 18. It is of the 2-4-2 design, as will be noted from a study of the illustration. At one time it was feared that the long shaft required for an eight-in-line engine would be subject to too great torsional or twisting strains. This might be true, but owing to finer steels and better production methods this is largely offset. A shaft for a modern eight-in-line engine is one of the most beautiful pieces of workmanship about the automobile.

V-Type Twelve-Cylinder Engine. At one time the twelve or "twin-six" enjoyed marked popularity, and, after a lapse of a few

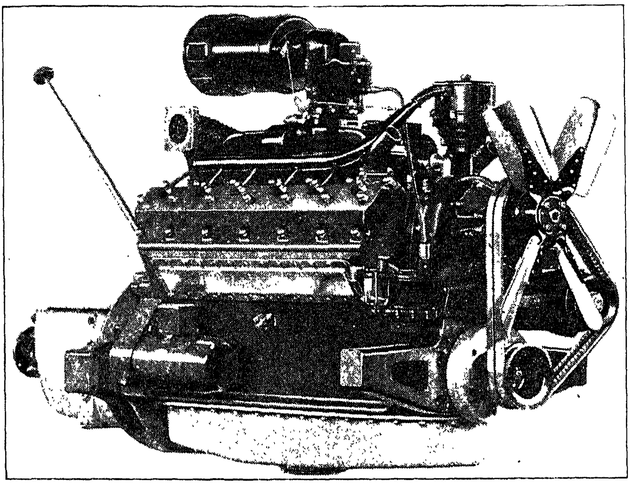


Fig. 19. Packard Twelve Engine

years, they were again popular. As in the case of the V-eight when compared to the four, the twelve involves no new crankshaft problems when compared to the six. The cylinders are set at 60 degrees, as a rule, so that the firing order was arranged to have the explosion cut in halfway between those for a six, which are 120 degrees apart, so as to provide a continuous torque.

In fact, the torque of the engine was so continuous, due to the overlapping of the various power impulses, that many laymen thought the transmission could be done away with. This did not

prove feasible. A good example of the twelve-cylinder practice was the Packard Twin Six, which has been in production for some years. A view of this appears in Fig. 19.

It must not be inferred that there is any inherent fault with the twelve-cylinder engine, owing to the fact that it was discontinued for a time. The design is good and is used in many airplane and in some boat installations as well as in a number of automobiles. Simplicity of other designs and lower maintenance costs have limited its field of service.

Theory of Crank Effort. *One-Cylinder Engine.* In a single-cylinder engine, four strokes of the piston are required to complete its cycle—the suction stroke, compression stroke, power stroke, and exhaust stroke. Note that only one of these strokes, the third, makes power. Roughly speaking, power is not produced throughout even the entire part of this stroke, but only through about four-fifths of it. Hence, in a single-cylinder motor with a 5-inch stroke, the piston travel for one complete cycle will be 20 inches. In only about 4 inches of this distance is power produced. (See Fig. 20.) Hence four-fifths of the total piston travel is a non-producer of power.

Two-Cylinder Engine. In the two-cylinder engine we have two power strokes in two revolutions, as follows:

	Inches of Power
First Stroke	
Cylinder *1* Suction	0
Cylinder *2* Power	4
Second Stroke	
Cylinder *1* Compression	0
Cylinder *2* Exhaust	0
Third Stroke	
Cylinder *1* Power	4
Cylinder *2* Suction	0
Fourth Stroke	
Cylinder *1* Exhaust	0
Cylinder *2* Compression	0
Total inches of piston travel representing power...	8
Total inches of piston travel.....................	20

Hence, the engine furnishes power during only 40 per cent of the cycle.

Four-Cylinder Engine. With the four-cylinder engine we have one power stroke during each half revolution of the crankshaft.

This gives us power during 16 inches of piston travel or power during 80 per cent of the entire cycle.

Six-Cylinder Engine. In the six-cylinder engine—the cylinders being the same size as those considered previously, and the stroke the same—we have 4 inches of power produced by each cylinder, making a total of 24 inches of power with a total piston travel of 20 inches. On the basis of the percentage values given in the two- and four-cylinder types this would mean an application of power during 120 per cent of the cycle. As this is impossible and as the

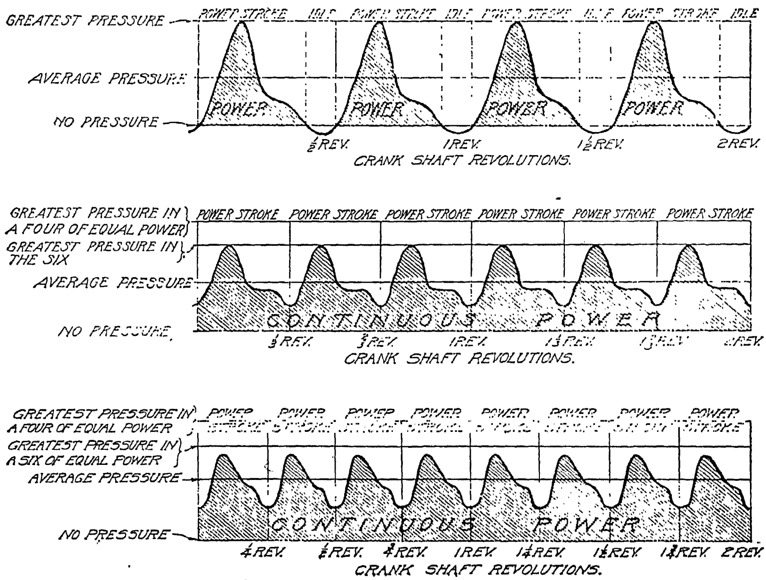


Fig. 20. Curves Showing Duration of Power in Four-, Six-, and Eight-Cylinder Engines

six cylinders are evenly spaced, the power in the cylinders must overlap each other. This results in continuous power. Diagrams showing the relation between the application of power in the four-cylinder, six-cylinder, and eight-cylinder are shown in Fig. 20.

Eight-Cylinder Engine. In the eight-cylinder engine—the cylinders being of the same size as those considered previously, and the stroke the same—we have 4 inches of power produced by each cylinder, making a total of 32 inches of power with a total piston travel of 20 inches. On the basis of the percentage values given

for the other types, this would mean the application of power over more time in the cycle than is possible, so, as in the case of the six-cylinder engines, there is an overlap. In this instance, however, the overlap is three times as great as in the six-cylinder, consequently the delivery of power is that much more even and continuous.

Twelve-Cylinder Engine. In the twelve-cylinder engine, with the same size cylinders as before, we have the same 4 inches of

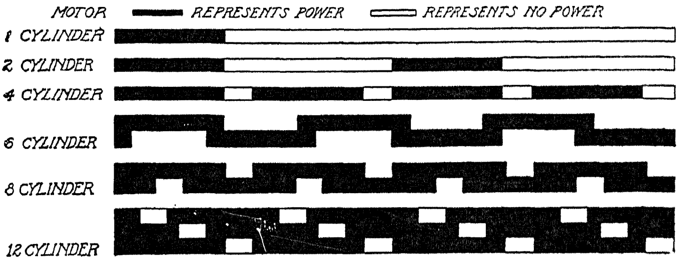


Fig. 21. Power Distribution Chart in Various Engines

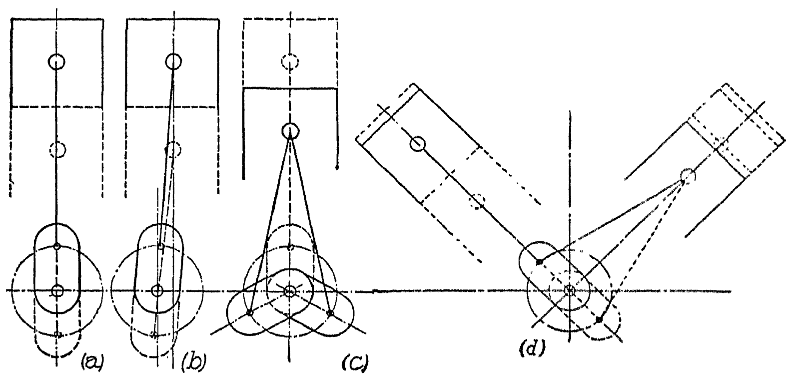


Fig. 22. Diagram of the "Dead Center" Problem

power in each cylinder, or 48 inches total, with a total piston travel of 20 inches, showing again a large amount of overlap. Here the overlap is seven times as great as in the six-cylinder form, consequently the output of power should be that much more even.

The diagram, Fig. 21, gives a clear idea of this distribution of power in the various engines discussed. The six-cylinder engine has a small overlap, while the eight-cylinder has a wide overlap.

The twelve-cylinder engine has a power overlap of two cylinders continuously, while the power impulses from three cylinders overlap part of the time, thus giving greater flexibility.

Effect of Dead Centers. In both the two- and four-cylinder engines, the cranks being set 180 degrees apart, each piston is always one complete stroke ahead of the succeeding one. When the cranks of the engine are in direct line with the connecting rod, Fig. 22 (*a*) the entire engine is on dead center. Fig. 22 (*b*) shows the same condition with offset cylinders.

In the six-cylinder engine, the cranks are set at 120 degrees, Fig. 22 (*c*), and therefore we have no condition when the entire engine is on dead center. It is impossible to have more than two of the cranks on dead center at once. Hence, there is never a time in the six-cylinder cycle when the engine does not produce power.

In the eight-cylinder V-type engine, the cranks are set 180 degrees apart, as in the four-cylinder, but the cylinders are set at 90 degrees, 45 on each side of a vertical, as shown in Fig. 22 (*d*). The connection of the side by side cylinders of each pair of fours to a common crank pin—the two number one cylinders, for instance, working on the first pin, the number twos on the second, etc.—eliminates all dead centers. This is one advantage of the V-type over the straight-line type, for the latter has a dead-center cylinder.

In the twelve-cylinder V-type, Fig. 19, the cranks are set at 120 degrees as in the six, but the cylinders are set at 60 degrees, 30 on each side of the vertical, the only difference from that in Fig. 22 (*d*) being in the angle. The crank-pin attachment in the twelve is similar to that in the eight, the first two cylinders working on the first crank pin, the second two on the second pin, and so on. Obviously the form of the crank and the setting of the cylinders at an angle eliminate all dead centers.

By comparison, the respective cylinder forms show these relative overlaps, the piston travel of 20 inches being the same for all: 6-cylinder—24 inches; 8-cylinder—32 inches; 12-cylinder—48 inches. The dead center consideration is entirely eliminated in the twelve-cylinder engine.

Horsepower. The unit of power used in the automobile is horsepower and is equal to raising 33,000 pounds one foot in one minute. The calculation is made in two or three different ways.

The brake horsepower is power actually delivered at the crankshaft and is obtained by test under working conditions. The indicated horsepower, which is obtained by a test indicator, shows the working pressure inside the cylinders.

There is one formula everybody should know who has an automobile or is in any way connected with the business and that is the method for calculating the taxable horsepower for license application.

$$\text{Horsepower} = \frac{(\text{Bore of cylinder})^2 \times \text{number of cylinders}}{2.5}$$

This is termed the S.A.E. formula.

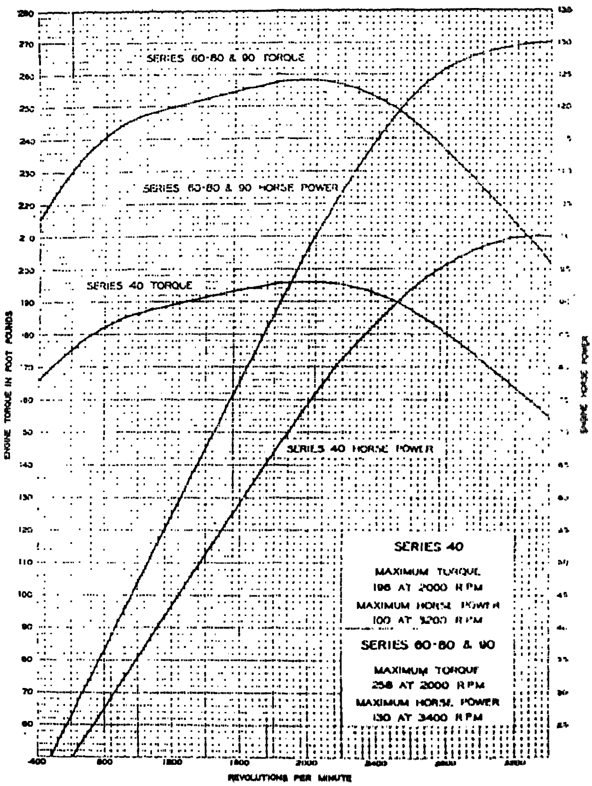


Fig. 23. Buick Engine Horse Power and Torque Curve Chart

ENGINE TROUBLES

When a customer drives his car into the shop for any kind of service, the first thing he is interested in learning is whether or not the man in charge can diagnose the trouble he is having and arrive quickly at the seat of it. It is a peculiar fact that most owners, when driving their cars into the garage, will proceed to tell the service man all about the trouble and even tell him, in many cases, the cause of the trouble without giving the garage man a chance to size up the situation himself. This is usually very unfortunate for the customer as he may indicate that he wants certain things done and the garage man, at his request, will go ahead and do them. Quite often, after they are done, the real trouble has not been corrected. It would be far better for both the customer and the service station if the diagnosis of the trouble were gone about in a scientific manner and not in a hit or miss fashion, as is the case when the customer tells the service man exactly what the trouble is.

Now if troubles are to be diagnosed in a scientific fashion, it means that the man who is diagnosing them must know what he is about. This means that he will have to make a thorough study of all possible troubles which may arise and must be thoroughly familiar with the symptoms. In other words, his job is just exactly the same as that of the family physician with reference to the human machine. When we go to the doctor to have our ills diagnosed, we will of course answer the doctor's questions; but most humans do not make the mistake of telling the doctor what is wrong before the doctor has made an examination. When they do, they are making a mistake which may lead to rather serious consequences. Just so it is with the diagnosis of troubles in the automobile engine.

Naturally people select their physician with an eye open to the service he can render them. They are looking for a cure for some ailment. They inquire among their friends as to who, within the medical profession, are really good. Then they will have every confidence in the ability of their chosen physician to help them.

The repair man, who has earned for himself the reputation for ability to diagnose engine troubles, is a much sought-after man in his

community. People will come to him on the recommendation of other friends. They come because they expect high-class service. They are willing to accept his word. In order to earn this reputation among the people of the community, too much exact information cannot be had. Experience is a wonderful teacher in all things and especially in diagnosing engine troubles. The following material is presented with the idea of helping the service man organize his thinking and plan his method of procedure when he goes about diagnosing any case of trouble presented to him.

Engine Fails to Start. 1. Notice the ammeter to see whether it is deflected as the breaker points open and close. If it is not, there is a likelihood that no current is being sent to the coil.

2. Inspect the gasoline supply. Many hours are wasted hunting other trouble when a dry tank is the fault.

3. If there is gas in the main tank, inspect the carburetor to see whether there is gas in the carburetor float chamber. This may be done by raising the needle valve from its seat until the carburetor floods.

4. If gas is supplied to the engine and the ammeter hand is deflected, then inspect to see whether there is a high-tension spark delivered to the plugs. A screwdriver may be used to short a plug to the cylinder block or head. Fig. 1.

5. If gas is supplied and a high-tension spark is detected and the engine still refuses to start, it may be due to: (a) spark plug points too far apart; (b) moisture around the spark plugs; (c) dirty spark plug porcelains; (e) a flooded engine, which means gasoline on the spark plugs or too light a mixture which will not fire; (f) engine out of time. The timing chain may have jumped or the ignition drive slipped. Check the engine time and check the ignition time.

6. No primary current at breaker contacts.

7. If no high-tension spark is noticed at the spark plug, proceed to check up as follows: (a) Remove the breaker cap, turning engine over until the contact points are closed. (b) Using the fingers to break the contact points, notice if a spark appears as the contacts break. Have an observer note the deflection of the hand on the ammeter, if any. (c) If no spark or deflection of ammeter hand is noticed, proceed as follows: First check the battery to see if it is in good condition or if any of the terminals are loose. Second, follow

the primary leads from the ignition switch to the coil and backward to the source of current. Third, check the contact point pig tails to see if they are loose. Fourth, inspect the ground of the ignition head to see if it is satisfactory.

Starting Motor Fails to Crank Engine. 1. Inspect battery to learn if it is fully charged.

2. Inspect battery terminal connection.

3. Inspect the ground wire to see if corrosion has set in where it is bolted to the car frame.

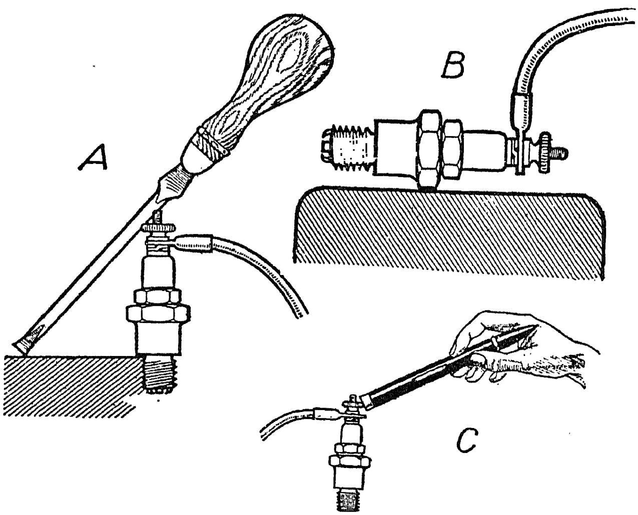


Fig. 1. *A*—Testing Spark Plug with Screwdriver
B—Checking Spark with Plug on Cylinder Head
C—Using Spark-Plug Pencil to Check High-Tension Circuit

4. Check up the starting switch to see if it is working.

5. Check the Bendix drive to see if the gears are locked. This may be remedied by rocking the car with gears set in high gear.

6. Test the battery posts to see if they are loose, being broken off within the cell jar.

7. Inspect the starting motor brushes to see if they are making proper contact with the commutator.

8. If a whirring sound is given off, inspect the Bendix spring. It is very likely broken.

9. If mechanical action is used to force the gears together, make certain that the springs are throwing the gears forward at the same time the switch contacts are closed.

Primary Circuit O. K. but No High-Tension Spark. In a case such as this proceed as follows: (a) Remove the distributor head and check the contact points as indicated for low-tension inspection. (b) Notice whether a snapping sound may be heard. If so, follow up to learn where it is. A short may have developed within the conduit carrying the high-tension wires. If no short has developed, the snapping sound will be within the safety gap in the coil. (c) Follow up the high-tension lead from the coil to the distributor cap to see whether there is a break or ground within it.

Sometimes the failure of the high-tension circuit is due to a burned-out condenser. This is a situation which will require the testing of the condenser. If a faulty condenser is found, remove it and replace with one known to be good. Many mechanics use this method of proving the condenser which is in the ignition system. If one of known value is used and the system works, then naturally the one which belongs on the system is faulty.

Gasoline Supply Fails. If the gasoline supply fails to reach the carburetor and there is gas in the main supply tank, proceed to check up as follows:

1. Check the carburetor to see whether gas can be brought to it by raising the needle valve from its seat and if no gas flows.

2. Check the vacuum tank to learn whether it is dry. If it is found to be dry, the cause may be: (a) Broken tubing either in the suction line, running from the engine manifold to the top of the vacuum tank or a broken main supply tube, running from the vacuum tank to the main supply tank. (b) The air valve within the vacuum tank head may have failed. (c) Inspect the main tank gasoline cap to learn whether the vent hole in it is open. Sometimes this is clogged with dirt, preventing air from entering the main supply tank. (d) Inspect the vacuum tank to carburetor feed line.

3. If there is gasoline within the vacuum tank and it fails to reach the carburetor, proceed as follows: (a) Remove the feed line and learn whether it is clogged. (b) Note whether the bottom of the vacuum tank is clogged and prevents gasoline flowing readily when the feed line is removed from it. If the gas line is open and the vacuum

tank is open, remove the feed from the bottom of the carburetor and inspect the screen strainer which is usually provided. Not infrequently these strainers clog, preventing gasoline feeding through the carburetor.

4. If engine gets too much gasoline: (a) Remove the vacuum tank head and inspect the float to see whether it has become logged. (b) Remove the carburetor float and inspect it to see whether it has become logged. (c) Inspect the float level to see whether it is too high, premitting too much gasoline to flow. (d) Inspect the float needle valve to see whether dirt may have gathered under it, thus preventing it being closed off.

Engine Stops Suddenly. If the engine stops suddenly and then will start after standing for a time, it would indicate that:

1. Gasoline supply line is partially clogged.

2. Main supply tank is almost empty, and gasoline is being brought forward irregularly.

3. If the trouble is within the fuel lines, proceed to check up as already indicated for these points. If no spark is supplied by the spark plugs, check this as indicated under the above electrical headings.

Engine Misses Fire. There are a great many causes which will produce this condition within the engine. Every owner and driver of an automobile knows some of the most common causes and as a rule will find these before going to the service garage for help. However, they should not be overlooked. Proceed as follows:

1. Check spark plugs to see whether all plugs and cylinders are firing.

2. If any one cylinder fails: (a) Inspect the ignition system for an air gap on spark plug too wide, Fig. 2; (b) broken spark plug porcelain; (c) loose or broken high-tension cables; (d) moisture on spark plug or about distributor; (e) burned-out coil or coil resistance unit; (f) carbon on plugs or fouled plugs; (g) fouled, broken, or cracked distributor head.

3. Check the engine for poor compression. If the compression in one cylinder is weak or lost, for any reason, the cylinder may miss fire at low speeds particularly and under certain conditions will miss fire at all speeds. Check as follows: (a) Valves may not be seating. Check valve clearance. (b) Valve stems may be corroded or gummed

and stick in closing. (c) Valve springs may be weak. Insert screw-driver between coils, Fig. 3, turning it to increase strength while testing. (d) Valve springs may be broken. This will be indicated by a clicking noise, many times. (e) Cylinder head may be loose or

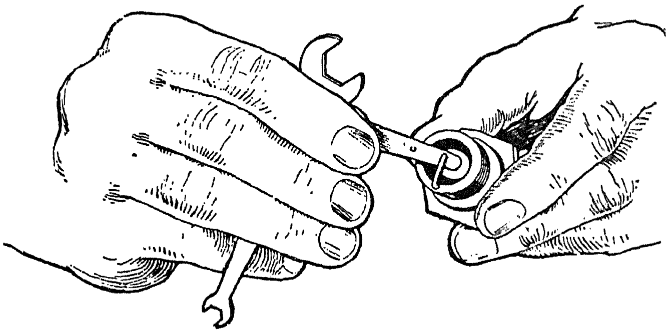


Fig. 2. Setting and Gauging Spark-Plug Air Gap

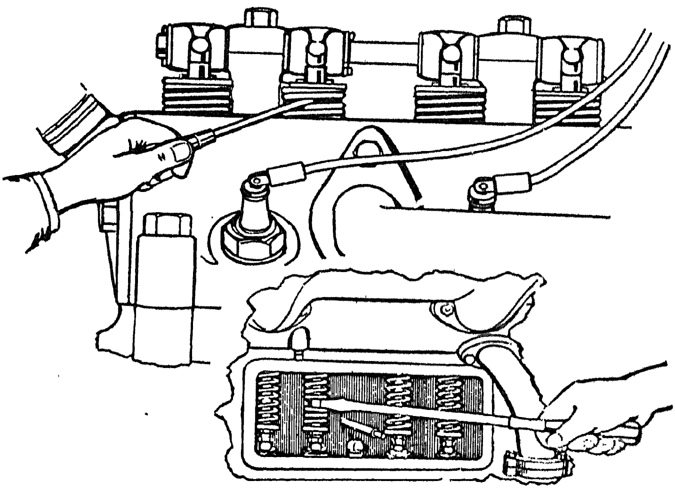


Fig. 3. Putting Pressure on Valve Spring to Detect Weak Valves

gasket blown. (f) Piston rings may be worn. (g) Cylinder may be scored. (h) Fuel supply line or carburetor may be clogged. Vacuum tank float may be logged. (i) Needle valve in float chamber of carburetor may be stuck, thus providing too rich a mixture.

(j) Carburetor adjustments may be improperly made. (k) The oil may be thin. (l) Valves may be burned or warped. (m) Water may be getting into the cylinder from a cracked cylinder head or valve port. (n) There may be an air leak around worn valve stems and guides and intake manifold gaskets. Make test with oil can and gasoline as shown in Fig. 4.

Engine Stops Suddenly and Cannot Be Started. As a rule this fault is due to a break in the low-tension circuit so that all cylinders fail to receive spark, or it is due to the gasoline supply being exhausted. More infrequent causes are such things as the ignition getting out of time or the engine getting out of time, as would be the case if the silent chain, driving the camshaft and ignition head

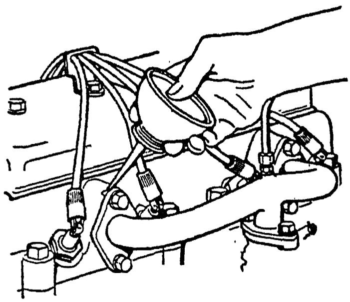


Fig. 4. Using Gasoline to Check Inlet or Intake Manifold Gasket Leaks

should become broken. When the motor has stopped, it should be checked as indicated for "engine refuses to start."

Engine Spits and Backfires. When an engine has been operating satisfactorily and suddenly begins to spit and backfire, it is usually due to the stoppage of the gasoline supply or to a misplaced high-tension lead from the distributor head to the spark plugs. Check these items and listen closely for any sound of a snapping spark, which would indicate a short.

When the gasoline system is at fault, the usual indication is spitting at the carburetor, which indicates that not sufficient gasoline is going through to give a full charge to the engine. Inspect for troubles in the gasoline feed line. Also check the valve action to see whether failu

Engine Overheats. An engine which has been operating at normal temperatures and suddenly gives evidence of overheating should have the cooling system checked along the following lines:

1. Inspect the radiator to see if it is properly filled or whether leaks have developed.

2. Inspect the hose connections to see whether leaks have developed around them.

3. If the water supply is O. K., check the top hose to learn whether it has become clogged from the rubber lining which is sometimes rotted away and thus causes stoppage. If this hose is O. K., inspect the lower hose.

4. Check the fan belt to see if it is in good condition, and turning the fan properly.

5. Check the fan to see whether it has sufficient lubricant and is free turning.

6. Remove the radiator cap and operate the engine at about a twenty-to-thirty-mile per hour rate, having the radiator filled, and note whether the pump causes the water to circulate freely, as will be noted from the action of the water at the top of the radiator.

7. Failing to find any trouble in the cooling system, check the spark to see whether it is late or retarded.

8. Check the carburetor setting to see if it has been disturbed; a mixture too rich or too lean will cause trouble.

9. Thermostat not opening.

10. Too much air shut off from radiator front by winter covering.

11. Too much alcohol in use in the system.

Chronic Overheating of Engine. Chronic overheating of the engine may be brought about by a variety of conditions. This is particularly true of engines which have seen considerable service.

1. Check up the points just given for overheating.

2. Check the water pump for a sheered or worn impeller.

3. Remove the radiator hose connections and flush out by means of a stream of water, forcing from the lower hose connection upward or in reverse to the normal water flow.

4. If this fails to clean out the radiator, have it removed and boiled out by a special radiator service station. An Oakite solution may be used for this.

5. When the radiator is off, use a stream of water to wash the dirt from the fins. Not infrequently dust and insects clog the flow of air through the radiator fins, causing overheating.

6. Check the engine to see whether it has an undue accumulation of carbon.

7. Inspect the oil supply in the engine and the quality of the oil and see whether the oil pump is working properly.

8. Check the ignition system thoroughly to see that it is in proper time and supplying sufficient spark.

9. Check the fuel system thoroughly and see that proper carburetor adjustment is secured.

Engine Refuses to Stop. If, when the ignition switch is turned off, the engine continues to run, this is a very definite sign of an overheated engine and one which is well filled with carbon. The remedy is, of course, to remove the carbon and locate the other cause for overheating. The continuous operation of the engine means that any charge being driven in is automatically fired by the intense heat in the combustion chamber, which usually means that the carbon therein is glowing, similar to a live coal.

Engine Has Poor Power. Here again there are a number of causes which may result in the engine having poor power. The expert service man will recognize the presence of those which are most usual, namely, faulty ignition or faulty carburetion. These may be checked up as previously indicated. Some faults which are not so readily located are also given here.

1. Check ignition.
2. Check the carburetion.
3. Check the engine temperature.
4. Check the oil for thin or poor quality.
5. Check the compression, which will give a line on valves, rings, and so on.
6. Check the exhaust system, noting whether the exhaust ports, muffler, exhaust tubes, and manifold are clogged. Sometimes this condition will destroy almost all the power generated within the engine, owing to back pressure.
7. There is a marked falling off of power when high altitudes are reached. As a rule this means going above 5,000 feet, although in some instances a similar falling off of power may be noted as low

as 3,000 feet. When an altitude of 8,000 to 10,000 feet is reached, power will fall off approximately 40 per cent. The carburetor may be adjusted to help this condition.

8. Motor accelerates but car does not pick up. This means the clutch is slipping, or gears or shafts are broken.

9. Motor seems to be laboring but pulling well. This would indicate the brake adjustment had become faulty. It might be due to a sheared center bolt on a rear spring. Rocks being thrown from the road and bending brake control is another cause. This condition is always to be suspected when lack of power is noticed immediately after relining or having brakes adjusted.

10. Low pressure in tires is the cause of loss of power in some cases.

11. Check the grade of fuel being used. Sometimes so much kerosene is introduced into the gasoline that the fuel mixture is almost impossible to carburet.

Engine Knocks. As a rule it takes some years of experience with the engine on the road and in the repair shop to enable the service man to diagnose engine troubles unfailingly. This is not to be wondered at, since there are so many conditions which may exist and again since there are such a great variety of engine designs. The following suggestions will be of help in locating engine knocks:

1. Carbon deposits are indicated by a lack of power, especially with low-grade gasoline, knocks on heavy pulling, engine overheating, and the distinctive pinging or detonation which is evident on a hard pull with the spark normally advanced. The remedy, of course, is obvious. Remove the carbon.

2. When the spark is advanced too far or too rapidly, pinging or sharp knocking will occur on rapid acceleration on a heavy pull or heavy going. This condition is usually detected by retarding the spark a bit to notice the action.

3. If the engine grows noisy rather suddenly and the noise seems to be through the engine in general, it would seem that the lubrication would be faulty as would be the case if the engine oil has become unduly thin or if the engine oil were almost completely exhausted. Unfortunately this condition is seldom detected until considerable damage has been done. If detected, of course, the remedy is draining out the poor oil and refilling with proper grade.

If not detected, rods or mains will be burned and pistons and cylinders scored.

4. Piston pin knocks are distinguished by a light metallic click when idling the engine and can be shorted out by means of a screwdriver shorting the spark plug.

5. If shorting out does not remove the knock, try holding open the exhaust valve for that cylinder, which will remove the pressure on the piston; and if a piston pin is the trouble, the knock will almost certainly disappear.

Never try to locate engine knocks with the motor cold. Hold one end of the screwdriver or rod to the ear, as indicated in Fig. 5,

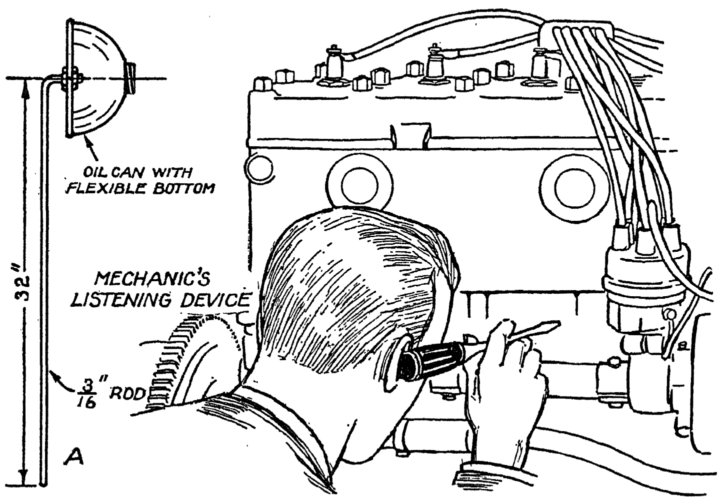


Fig. 5. Listening for Engine Knocks

placing the other end at different positions on the motor. In this way, the particular spot at which the noise is greatest can be located. (Note: Some mechanics make up a "listener" along the lines indicated at *A* in Fig. 5, which is merely a welding rod soldered to the bottom of a common oil can.) If the noise seems to be at the top of the engine, it is likely within the cylinder and by shorting out the spark plug for that cylinder you can tell whether or not you have definitely located it. Troubles within the cylinder may be of three kinds—worn piston pins, worn or loose pistons, and faulty piston

rings. When searching out troubles with reference to loose pistons or worn rings, it is difficult to make certain of them by shorting out the cylinder. A better plan is to use an oil can and squirt a quantity of engine oil into the vacuum air line, which runs from the engine manifold to the top of the vacuum tank. This will insure a quantity of oil being drawn into each cylinder and around the rings and pistons with the result that any looseness there will be cushioned and taken up and the noise will be stopped. If stopped, it indicates that the trouble is located.

A loose connecting rod is indicated by what is termed a dull thud or knock. It is not as sharp as the piston pin rap or nearly as heavy as the main engine bearing knock. It is usually noticed when the engine is running at a fair speed and is rapidly decellerated. Loose crankshaft bearings or "engine mains," as the mechanics term them, are indicated by a very heavy thud or deep knock or bump which is secured when the engine is under load or when rapidly accelerated. The indication for a loose or worn timing gear is a pronounced rattle. Sometimes this knock is almost identical with that of a piston pin or very loose connecting rod in a light car. A loose flywheel will cause practically the same indication as loose timing gears but can be easily differentiated since these two points are at opposite ends of the engine.

End Play in the Camshaft or Crankshaft. End play in the camshaft may usually be detected by placing a strain on the forward end of the shaft, keeping it thrown backward. End play in a crankshaft is very often hard to find. If pressure can be placed on the flywheel or on the forward end of the shaft in such a way as to hold it in one position and the noise disappears, the indication is certain.

Dry pistons and cylinders are indicated by a sort of "grunting" sound as the engine is turned over slowly by hand or under its own power. This condition may be due to failure of one of the supply lines of the lubrication system, or low oil supply. It sometimes occurs when new rings are fitted too snug.

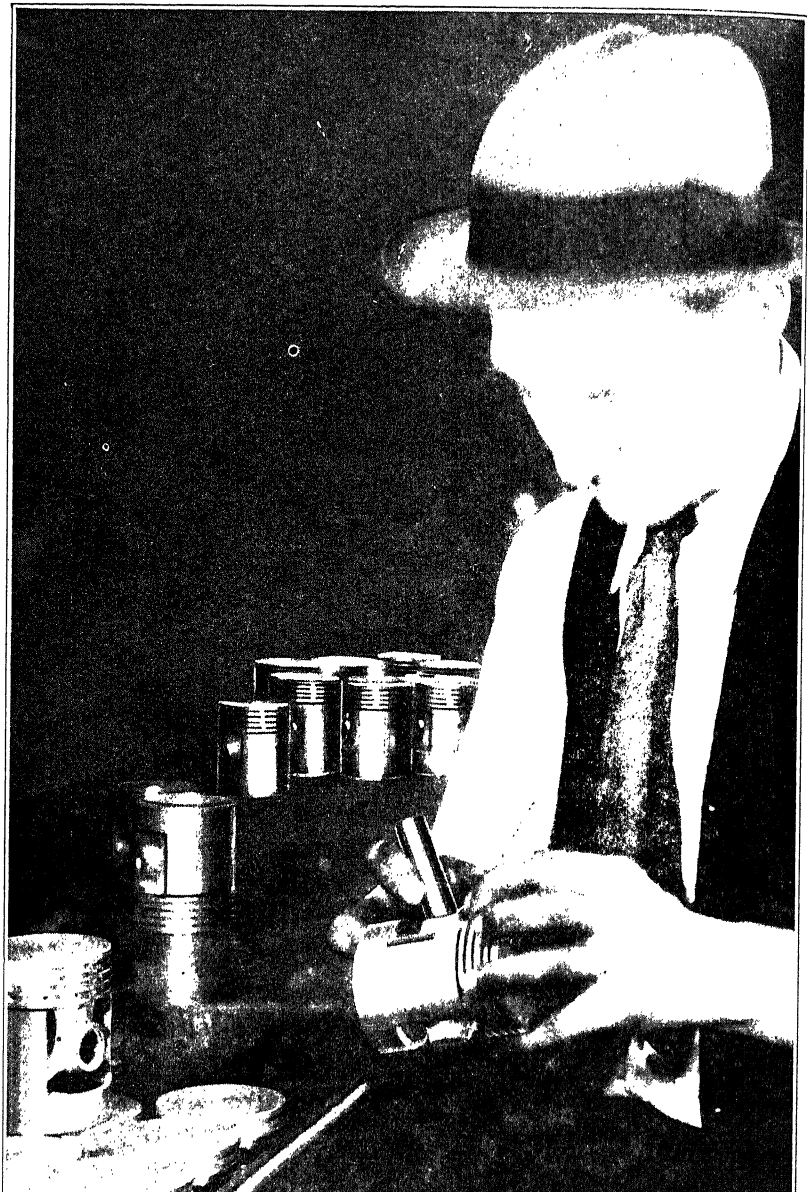
When a distinct click is heard when standing aside of the motor which is running at idling speed, this click, being in time with the camshaft, is usually accepted as a faulty valve lifter or cam. Sometimes the cam has been worn rough or the valve lifter may have become scored because of too close a seating of the valve clearance. Remove

the inspection covers from the valve compartment and testing with the screwdriver will usually determine if the valve lifter is at fault. Sometimes it is merely too wide a gap or too much clearance. When setting up valve lifters, the same clearance should be given to all intakes and all exhausts. This will make a rhythmical sound rather than a knocking sound, even though the clearance be a bit more than that advocated by the engine builder.

Hissing or blowing sounds usually indicate that the pistons and piston rings are worn within the cylinders, allowing the gases to be blown by the piston and rings, first on compression and again on the power impulse. This indication may readily be detected by means of an inspection of the breather tube. If the condition is bad, considerable quantities of vaporized oil and other gases will be blown from the breather tube.

A grating sound within the timing gear cover will, as a rule, indicate that the silent chain is too loose. At times it will swing outward into contact with the timing gear cover, grating or scraping on it as it passes. The repair, of course, is obvious. Seek out the adjustment and tighten the chain. In full pressure oiling systems, it sometimes happens that what is termed an "oil ram" is set up. This is rather a distinct click, something on the order of a piston pin knock. It will occur when the oil supply is cut off by the rotating crankshaft and is a very similar sound to that secured when the water is turned off at the faucet in the city water system.

With the introduction of the high-compression engine, certain conditions have had to be contended with in the combustion space which were different from those with which mechanics were formerly familiar in regard to the low-compression engine. In the first place the spark may not be carried so far advanced. The higher the compression, the further back the spark must be set or retarded in order to prevent knocking under normal operating conditions. Another thing which should not be attempted is to operate such an engine on low-grade fuel unless this is an absolute necessity. Under all circumstances the specially prepared fuels for high-compression engines should be used.



PISTON PINS MUST FIT BY A GREAT DEAL LESS THAN A "HAIR'S BREADTH"

DISASSEMBLING AN ENGINE

Inspecting Engine for Need of Repairs. When the diagnosis of the engine trouble shows the need of removing the engine, the car is placed in a position where a crane is available overhead or where there is a chain block or other lifting means available.

The first step in the best garages is that of covering the fenders with coveralls and protecting the seat, steering wheel, and other

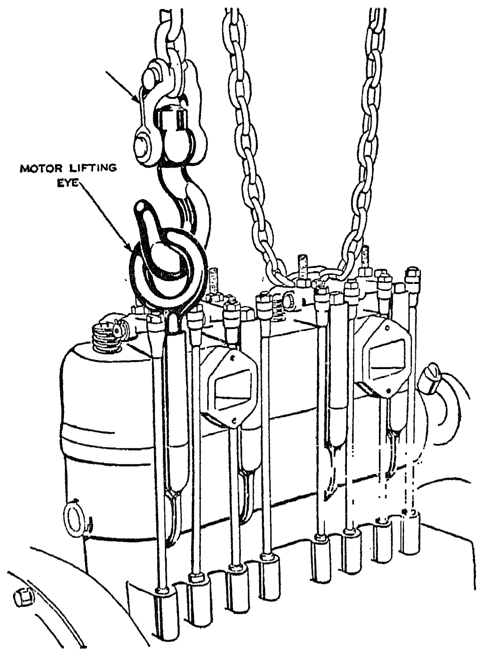


Fig. 1. Using Chain Block for Lifting Engine from Car Frame

portions in like manner. This will save many complaints from the customer. Then disconnect the storage battery so as to avoid danger of short circuits. Next drain the water from the cooling system and remove the hood from the car. Disconnect water connections and loosen radiator. Disconnect head light wires and if the head lights seem to be in the way, remove them to prevent damage. Remove all wires from the electrical connections which may interfere with

lifting the power plant as a unit. Remove the floor boards from the driving compartment. Remove sod pans. Loosen the engine mountings, front and rear. There will be three to four or six of these. Disconnect all tubing, such as gasoline supply, oil pressure indicator, oil cleaners or rectifiers, etc. Inspect the rear of the transmission and disconnect the propeller shaft or universal joint, as the case may be. Make a final inspection to see that no part of the engine or transmission connections have been missed. Provide a hook or eye, Fig. 1, to which the chain lift may be attached. In most garages the mechanics supply themselves with a screw eye which has a spark plug fitting on its lower end, which is welded up. This device is

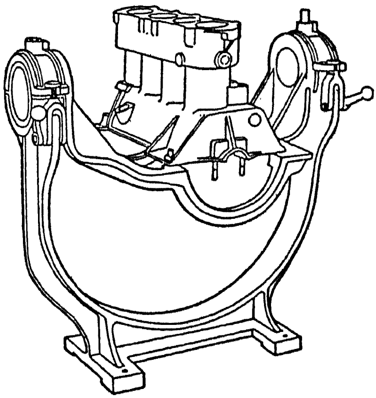


Fig. 2. Mechanics in the Better Shops Use an Engine Stand for Mounting the Engine When Repairing It

screwed into the spark plug hole which is nearest the center of the power plant and will come nearest balancing the engine on it. Some mechanics make up an attachment which goes under two of the cylinder bolts, having a ring in its center. If nothing of this sort is at hand, use a square linked chain with a hook and cross it under the engine pan at the forward end between the transmission and the engine so as to form a cradle. Use extreme care when lifting the engine to see that no part is bound or no damage done to parts which may have been overlooked when disassembling. Remove the engine to the engine stand, Fig. 2, bench, or sawhorse, as the case may be, and drop it into position.

Cleaning the Engine. Do not make the mistake of starting to disassemble the engine until the outside is thoroughly cleaned. This is the common mistake made by indifferent mechanics or partially trained men. To neglect it is to invite trouble later on when parts eventually will have to be cleaned. There is only one exception to the general rule and that is where cleaning tanks are available and the parts are to be disassembled, taken to the cleaning tank, and cleaned therein. Small garages, as a rule, depend upon the use of kerosene for washing off the accumulation of dirt and grease on the outside of the engine. The power auto laundry machine will do the work quickly.

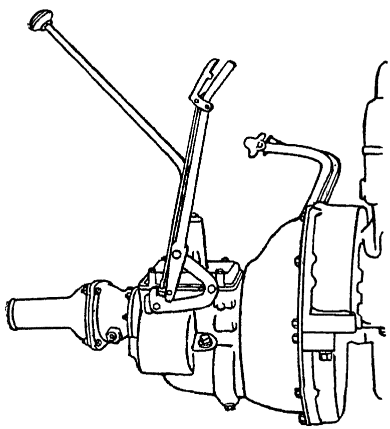


Fig. 3. When the Engine Has Been Lifted from the Car, Remove the Transmission

Removing Transmission. It is generally possible to remove the transmission after the power unit has been cleaned and disturb no other parts. This is done so as to get it out of the way for the work which is to proceed upon the engine. See Fig. 3.

Removing Fan and Fan Pulley. Different engines have different construction with reference to these several units. As a rule, the work may be done as suggested in Figs. 4 and 5, making use of the steel pullers or gear pullers for this work.

Removing Electrical Equipment. When the engine is first placed on the block, all electrical equipment should be removed. The starting motor is fastened on by means of a flange with four bolts

in most cases; and in some cases it is a different type of S.A.E. fitting and one set screw only needs to be backed off. The generator, as a rule, is mounted by means of a flange and the method of removing is easily discerned. The ignition head is the one unit which is driven strictly in time with the engine. There is no need of attempting to mark its timing as it will be retimed when the engine is assembled. Remove the ignition head as a unit and lay it away.

Removing Timing-Gear Cover. Timing-gear covers are provided to protect the gears or chain from dust and dirt as well as to

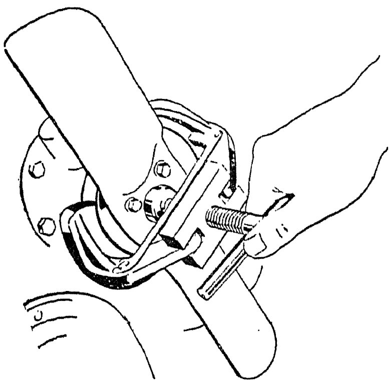


Fig. 4. Use a Puller to Pull the Fan

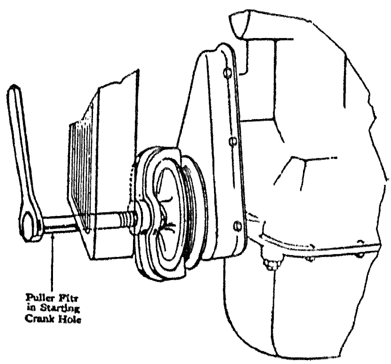


Fig. 5. The Fan Drive Pulley May Be Removed by Means of a Puller

retain the oil. Sometimes the front mounting of the engine is carried through the timing-gear cover, in which case it is heavier than otherwise. In many cases they are sheet metal stampings. In practically all cases they are held to the engine by means of cap screws. Run these out and very carefully insert a screwdriver, breaking the gasket joint and lifting the cover away.

Removing Cylinder Head. If the spark plugs have not been removed, they should be removed at this time and inspected for condition as they will tell you considerable about the condition of the engine. Refer to the engine trouble diagnosis for further information. Use a speed wrench and turn out the cylinder head bolts. Remove the cylinder head nuts and place these in a proper receptacle to prevent their loss. Remove the cylinder head by pulling on it or driving up on it with a soft hammer, such as a lead hammer or rawhide mallet.

Do not make the serious mistake of driving a screwdriver between the cylinder head and the top of the cylinder block as this is certain to ruin the gasket and in many cases has been the cause of damaged surface on the head which makes it very difficult to prevent compression leaks. It is unworkmanlike. Many mechanics make it a practice to loosen the cylinder head nuts or bolts before removing the spark plugs. They use the hand crank then to turn over the engine and this will break the seal or joint between the cylinder head and the gasket. Do not remove the nuts or bolts. Simply back them off about two or three turns then, when the engine is turned over, the compression will force the head upward a small distance.

Removing the Oil Pan. The oil pan or oil sump, as it is called, is made from pressed steel in a great majority of cases. In some cases it is made up from cast aluminum or cast iron; seldom the latter. When removing the pan, make certain that all external oil connections, such as tubes running to the oil pump, are disconnected. Remove all capscrews, etc. In some instances these screws are run in from the end. Make a careful inspection to see that none are missed. Also use extreme care to see that the pan edges are not damaged when the gasket joint is being broken. The same amount of care should be exercised here as with reference to the head, as it is impossible to make an oil tight joint if surfaces are damaged.

Removing Timing Gears. Make a careful inspection of the timing gears to see how they are marked. Sometimes chains are used in connection with sprockets, rather than the timing gears, illustrated in Fig. 6. If the chain has been used, wipe the oil from it and the sprockets and see whether you can locate the timing marks. These will be apparent in most cases. Refer to Fig. 7, which illustrates this type of construction and one method of marking. When inspecting timing-gear marks, the engine should be placed with piston No. 1 on top dead center, the exhaust valve just closing and the intake valve just starting to open. The marks should then coincide. Cam gears are bolted to the end of the camshaft. As a rule, it is not necessary to remove the cam gear.

The crankshaft gear is, in most cases, a press fit on the end of the crankshaft, a key being used to prevent its turning on the shaft. Fig. 6 illustrates the use of a gear puller. This may be purchased or may be made up, as occasion warrants. Under no circumstances

should a gear be driven off with a hammer, as it is almost certain to damage the teeth and make a very noisy operating engine or result in broken gears or other parts.

Removing Pistons and Connecting Rods. The engine should now be turned over, if this is possible, and the cotter keys removed from the connecting rod bolts. Inspect the connecting rods and caps to see that they are marked $\frac{1\text{-}2\text{-}3\text{-}4}{1\text{-}2\text{-}3\text{-}4}$, and so on, on the camshaft side. Next use a socket wrench and spin off the connecting-rod bolt nuts. Extreme care is exercised at this point with reference to inspecting connecting-rod bearings and learning the position and

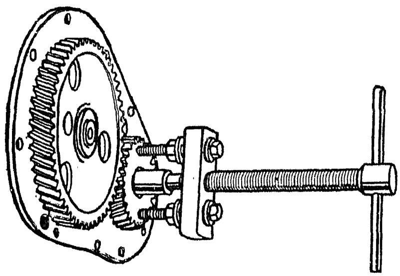


Fig. 6. After the Timing Gear Cover Is Off, Pull the Crankshaft Gear

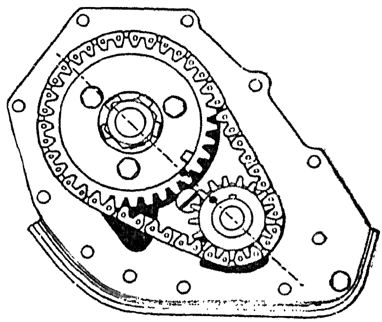


Fig. 7. Inspect Chains and Sprockets to Learn Method of Marking before Removing Chains or Gears

number of shims. Ordinarily the mechanic will drop the lower half of the connecting rod while mounting the shims in position on the cap, or on the upper half, after which he will push the rod to the side of the crankshaft and reinstall the lower half of the rod bearing so that he has the shims in exactly the position they were originally. Later, when testing the bearings, he may remove the shims if such will be the need, but he is never caught with a bearing which is to be refitted without any idea of what the original fit was. Do not lose these shims or misplace them.

Some manufacturers of cars design the engine so that the piston may be pushed up through the cylinder block, the big end of the connecting rod being small enough so that it will pass through the cylinder, Fig. 8. This is generally true of four-cylinder cars but not usually the case in six-cylinder, where the bore of the cylinder is

small. In that case it may be necessary to pull the piston downward, as illustrated in Fig. 9. In some cases it is almost impossible to pull the piston downward and impossible to take it up with the connecting rod on it. In such cases it may be necessary to push the piston up, removing the piston pin and then take the rod out at the bottom and the piston at the top. This is rarely the case, however, although the beginner might feel that it is the only possible way. In many cases the crankshaft is machined so that by putting it in

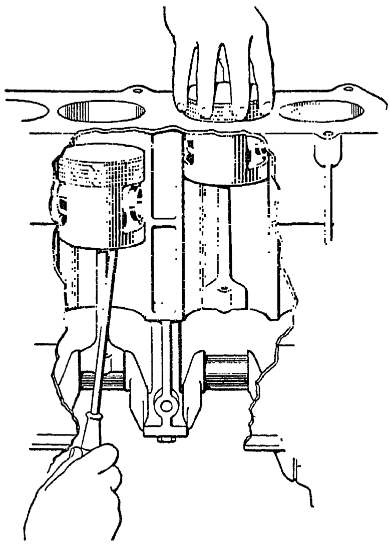


Fig. 8. If the Lower End of the Connecting Rod is not Too Large, Pistons May Be Pulled from the Top

one certain position the piston assembly may be pulled downward. This requires extreme patience and skill.

Removing the Flywheel. To remove the crankshaft it will be necessary to remove the flywheel. This may entail the job of removing the clutch if the clutch is built into the flywheel, as is common practice. (For methods of removing clutches refer to chapter on "Clutches and Transmissions.") The flywheel is held in position by means of heavy cap screws which bolt it to the flywheel flange. Inspect the flywheel and learn if it is marked with reference to the flywheel flange or crankshaft. If it is not marked, place two center

punch marks—one on the flange of the crankshaft and one on the flywheel itself—then when you are replacing it no trouble will be experienced in getting it back in its original position. The reason for this care is the fact that in the best practice the flywheel and crankshaft are balanced as a unit when leaving the factory.

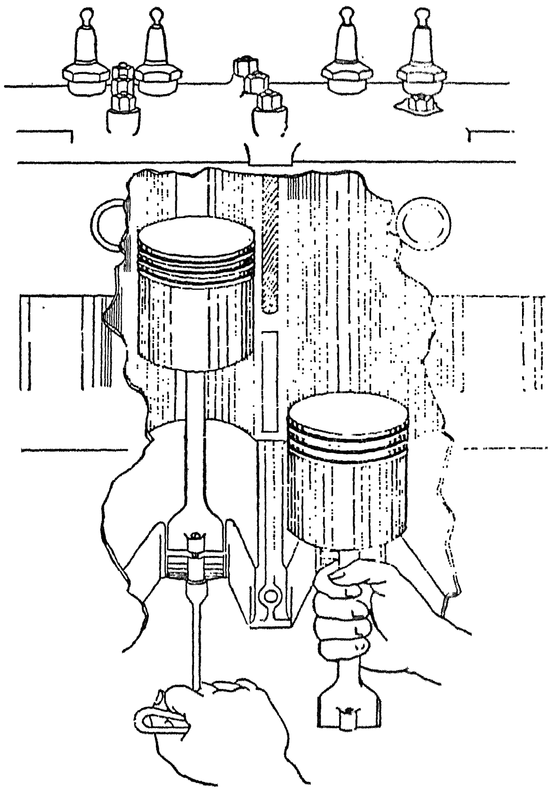


Fig. 9. If the Lower End of the Connecting Rod Is Too Large, Pistons May Be Pulled from the Bottom

Removing Crankshaft. When removing the crankshaft, it is necessary to remove the locking wires or cotter keys from the main bearing studs, after which the castellated nuts may be turned off by means of a speed or socket wrench, Fig. 10. Note whether the bearings are marked to identify them. Mark, if necessary. By no means should an end wrench be used on these nuts as the nuts will

be rounded off. It will be found that extreme force is sometimes necessary to start these nuts. That is because they have been tightened very snug when the job was originally assembled. When reassembling, an equal amount of force should be used in order to prevent any likelihood of the job failing. After the nuts have been removed, carefully lift up on the lower half of the main bearing,

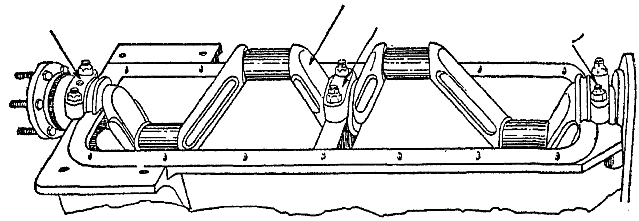


Fig. 10. When Removing Crankshaft, the First Step Is to Remove the Main Bearing Caps Indicated by Arrows

watching for shims and noting the position of any felts which are used for oil retaining. Under no circumstances misplace or mix up these shims, but lay them aside or have them retained on the main bearing studs. (This is possible if the engine is in the inverted position.) When all caps have been removed, the crankshaft may be lifted as indicated in Fig. 11.

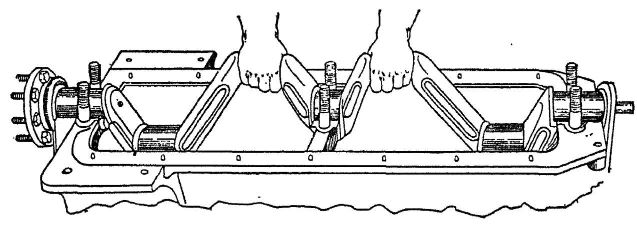


Fig. 11. Lifting Out the Crankshaft

Removing Oil Pump and Water Pump. Make careful inspection of the engine to learn whether it will be necessary to remove the oil and water pumps. In many cases the engine may be gone over rather completely without doing any work on these two items. The most usual need in the case of the water pump is to have the shaft replaced and the pump glands repacked and in some cases rebushed.

The most usual failure in the oil pump is the oil-pump gears. When rebuilding an engine, the pump should be opened up and these gears inspected. If they show considerable wear, they should be replaced as their cost is very slight.

Removing Valves. The valves may be removed easily by means of a valve spring compressor or what is known as a valve lifter. Before removing the valves, inspect them to see that they are marked for position. No. 1 is always the first valve at the front of the motor and the other valves are numbered in order. The cylinder block or head is never marked. Compress the spring with the lifter, removing the locking device which may be a pin, horseshoe, or split washer. The valve is lifted upward and the spring removed. Lay these parts away in order. Make an inspection of the engine to learn what parts should be repaired or replaced.

INSPECTING PARTS FOR REPAIR OR REPLACEMENT

When disassembling an engine, the repair man will note as he goes along the condition of the different parts and the likelihood of the need of replacing these parts. Owing to the fact that the subject is so large, this particular part of this treatise on automobile engineering will just touch, in a very general way, the things to be looked for. In succeeding chapters of the book more definite instruction is given and parts are illustrated so that the reader is able to make a very definite study of conditions with reference to any particular part. For instance, if thoroughgoing information is desired on cylinders, the reader will turn to the chapter covering cylinders and cylinder repair, and so on with reference to any other feature of the engine. The following suggestions will give the repair man an idea of the most commonly needed repairs.

Gaskets. It is good practice to replace all gaskets when rebuilding an engine. The surfaces to be joined are scraped clean and free of old gaskets and shellac. New gaskets are fitted in a very careful manner. In many cases paper is used. The point between the crankcase and the crankcase pan is sealed by means of cork or special gasket material, such as Vellumoid. The cylinder-head gasket, of course, is a specially prepared gasket in all cases, of copper, bronze, and asbestos. Many of the gaskets are made from a special nonburning material such as asbestos, with the copper wire woven into it.

Many of the smaller manifold gaskets are of copper and asbestos, Fig. 12. Do not take a chance on rebuilding an engine with old gaskets when the cost of new ones is such a trivial matter. Make them air tight, oil tight, water tight and gas tight. Use new gaskets.

Cylinders. Cylinders should be inspected for undue wear. If they are out-of-round, scored, or otherwise misshapen, they should be reconditioned. Inspection is made by means of precision instruments, such as the cylinder gauge and inside micrometers.

Pistons. Inspect the clearance of the piston by means of feeler strips or by means of inside and outside micrometers. Look the piston over and see if it is scored. Measure it to see if it is out-of-round. Inspect the ring grooves to see what clearance the ring has in the groove and whether the grooves are worn tapered. Check the piston for cracks. Inspect it also for wear in the piston pin. If it is to be used over, clean it thoroughly inside and out.

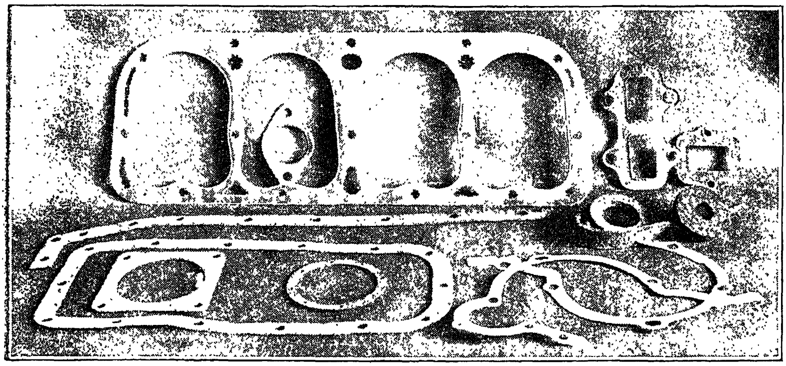


Fig. 12. Gaskets of Paper, Cork, Felt, Copper-Asbestos, and Graphite-Wire-Asbestos Are Used to Seal Joints

Valves. If the engine uses poppet valves, they should be carefully checked for warping, burning, or wear on the valve stems. Sometimes the heads have been refaced until they seat too far down into the cylinder block or into the cylinder head. If they are unduly worn, discard them in favor of new valves. Test the valve springs to see if they come up to the specifications of the manufacturer. They should, as a rule, have not less than 45 pounds push when compressed to the normal closed valve position. On open valve position they will show at least twice this, as a general rule.

If the valve locks are not in excellent condition, they should be discarded in favor of new ones.

Valve Seats. The valve seats in the cylinder head or in the cylinder block may sometimes be worn badly so that it is impossible to seat a new valve or the old valve, properly. In such cases the best practice is to replace with a new valve seat ring.

Piston Pins. When checking up the piston, it is well to check up the piston pin to see whether it is unduly worn. In some cases, such as the Ford Model T, the piston bushing may need to be pressed out and new ones pressed in, after which the piston pin is fitted by reaming. Check the amount of wear and decide on the proper size of

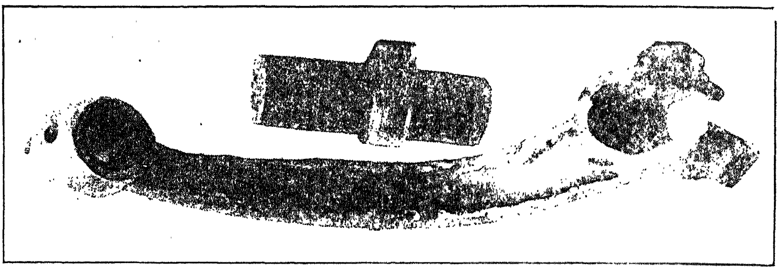


Fig. 13. Failure of a Rod Bearing Has Wrecked Many an Engine

oversize pins, if they are to be replaced, checking the piston also for the piston pin locking device. If it is worn, threads stripped, or otherwise damaged, the piston should not be re-used.

Connecting Rods. Check the connecting-rod bearings to see whether they are broken in any wise or whether they have become loose. If loose, they should be replaced. If badly burned, Fig. 13, they should be replaced. Check the upper end bronze bushing, if such is used, to learn its condition and whether it will stand reaming when fitting oversize piston pins.

Piston Rings. Piston rings are very seldom re-used unless the job has not been in service for more than 5,000 miles. If down for other work, it is a good plan to replace the old rings with new ones. Always maintain rings which are to be re-used in the proper order, Fig. 14, so that they may be returned to the engine in the original cylinder and in the original groove of the piston.

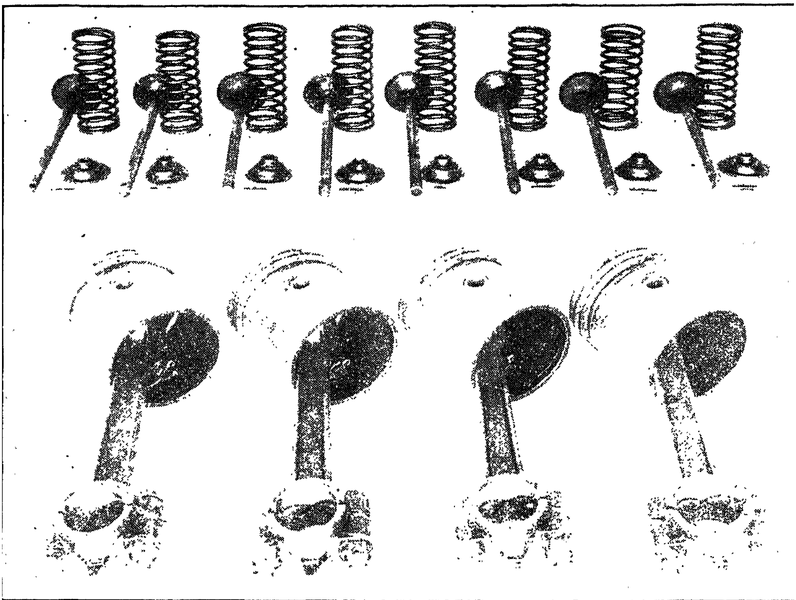


Fig. 14. Clean Up the Engine Parts and Lay Them Out in Order for Inspection

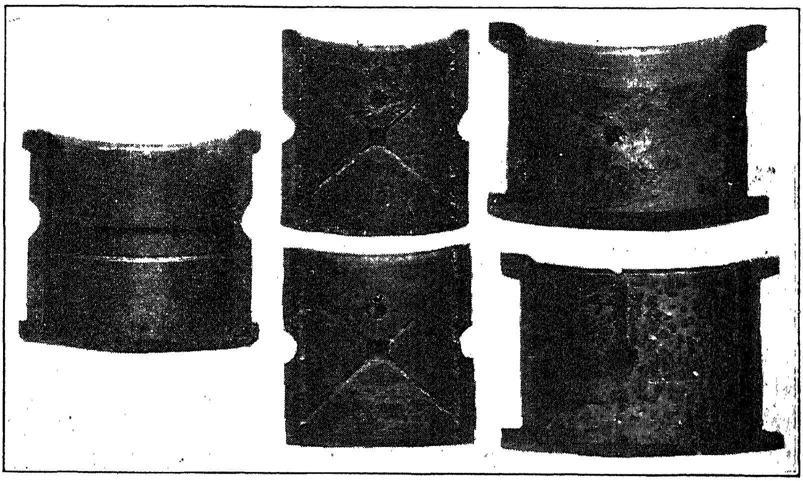


Fig. 15. Burned Engine Bearings—One Unburned at the Left

Main Engine Bearings. Main engine bearings, as a rule, may be refitted unless they are of the Chadwick Close Limit Renewable Bearings, in which case the entire set should be discarded in case repairs are needed and a new set installed. These require no scraping or fitting of any kind. Main engine bearings in general are of two types—those which are sweated and cast into a crankcase and those die-cast and fitted into a machined bearing support. The latter type are easily removable by removing one or more brass screws. If the bearing has been broken or is badly burned, Fig. 15, it is a good plan to remove it and replace it with a new one.

Crankshaft. It is seldom necessary to replace a crankshaft during the life of the average engine. In some cases the crankshaft may be polished and the bearings refitted but in other cases the crankshaft is reground and new bearings fitted to it. Always examine the journals of the crankshaft—both the main bearing journals and the connecting rod pins—to see whether they are scored or badly out-of-round. If they are out-of-round more than the usual limits of .002 inch, it is a good plan to have them reconditioned.

Camshaft. It is very rare indeed that a camshaft needs to be replaced or that camshaft bearings cause trouble. Occasionally the play within the camshaft bearing will cause a slight knocking, but this is very unusual. It is more likely the knock from a camshaft will come from end play, which is usually adjustable. Noises are frequently attributed to camshafts, which are really in the cam gears. The old Ford Model T camshaft used a split camshaft bearing and these were replaced when rebuilding. The amount of bearing surface in these bearings is much smaller than ordinary, which accounts for the need of replacing. It is a good plan, however, to inspect the cams to learn whether they have become worn, Fig. 16. In a few cases where the factory has failed to properly heat-treat the cams, it will be found that the roller type of valve lifter has worn a track into the cam itself. The only remedy in such cases is to replace the entire camshaft, which is a one-piece forging. Slight scratches on a cam, which might be caused by a stuck cam follower of the mushroom type, may be polished out by means of an emery cloth or very fine oilstone.

Cam Followers. Cam followers are usually good for the life of the engine, although they may become slightly noisy after a time.

Inspect them very carefully to see whether the face on the cam follower, if it is of the mushroom type, is scored or badly worn. If it is, it should be replaced. Inspect the rollers of cam followers of that design to see whether the pin and the hole in the roller are a snug fit. If wear of a marked degree has occurred, discard the roller and pin, replacing them with new ones.

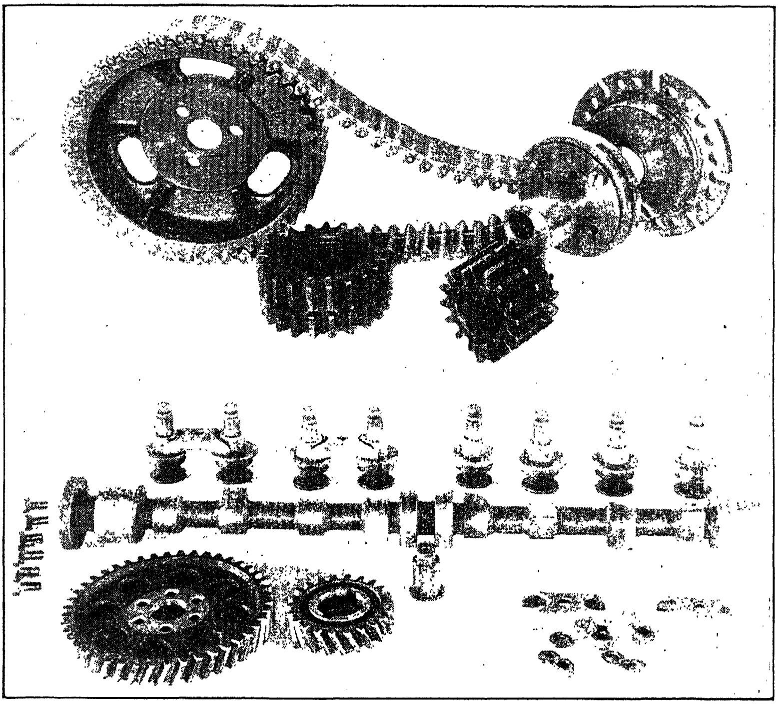


Fig. 16. Timing Gears or Chains, Camshafts, and Valve Lifters Are a Common Source of Disturbing Noises

Sometimes the valve lifter adjusting screw becomes worn and hollowed where the end of the valve rests upon it. In such cases it is a good plan to replace the screw or grind the face of the screw true again. If this is not done, trouble will be found when checking the valve clearance.

Oil Tubes. Inspect the oil tubes very carefully to learn if there are any broken or cracked parts. This is particularly recom-

mended with reference to those tubes which are within the crankcase and oil pan, since under no possible circumstances would the driver be able to know if one of these tubes failed before serious damage was done. External tubes should always be in good condition, but a leak here is usually found before damage occurs.

Oil Pump. Make a very careful inspection of the oil pump and especially of the gears where the gear type pump is used. Not infrequently these gears become so worn that they fail to deliver the proper pressure and proper amount of oil. If they show undue wear, they should be discarded, replacing them with new ones.

Timing Gears. After an engine has seen service from 25,000 to 50,000 miles, the timing gears will have become worn to such an extent that they are certain to be more or less noisy. While they have been quiet in the engine, they will grow noisy after it has been rebuilt. If they show more than .010 inch play between the gear teeth, they should be discarded and new ones installed if a quiet operating motor is desired. Where the fabricated gears are used (these are of many types and designed for quiet operation) it will be found wear is faster than where a steel or bronze gear has been used. The noise coming from this undue clearance is not so noticeable, but in all cases it is advisable to replace this type of gear after considerable service.

Timing Chains. Timing chains are tested in several ways. The most usual is to open the chain at the point provided for this and lay it out flat on the bench. First, push it together as far as it will go, taking up all the slack that way. Next, mark the position of the ends and then stretch the chain until the slack is taken up. If the chain stretches more than one inch, it is a good plan to replace it. Another method of testing is to swing the chain sideways as it lies on the bench, noting the amount of curvature. If this curvature is more than an inch or so, it indicates considerable wear. Also inspect the chain to see if there are any broken links. These are certain to cause further damage. Carefully inspect the sprockets where the chain type of drive is used. These are not infrequently worn until a very sharp edge shows on the spocket teeth. If they are worn, they should be discarded in favor of new ones.

Flywheel. Inspect the flywheel carefully to see whether the flywheel bolts are loose. If so, new ones should be installed. Also

note whether the teeth on the flywheel have become damaged from contact with the Bendix or other starting motor drive. This is a very common point of failure on almost all engines. If the teeth have been badly chipped away or broken by the starting motor pinion, a new ring should be installed or a new flywheel—this point to be determined by the facilities at hand. Do not replace a flywheel in the engine when the teeth are badly chipped.

Water Pump. Inspect the water pump most carefully and learn

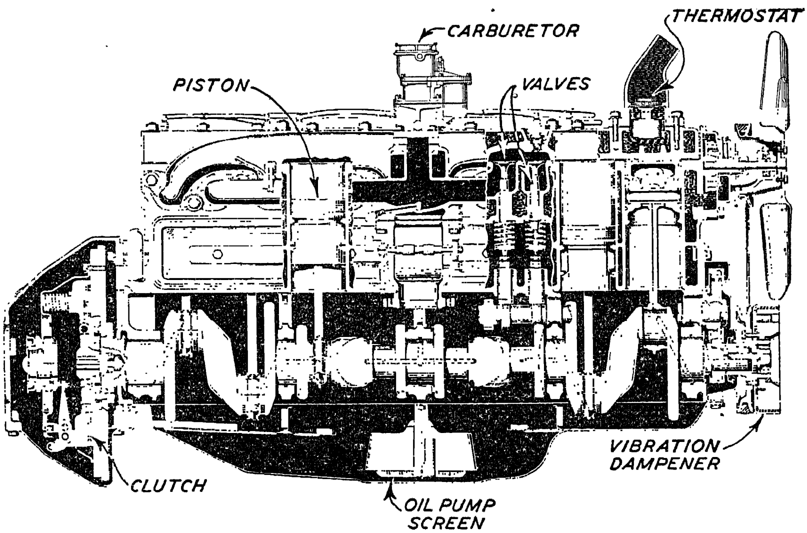


Fig. 17. Side-Sectional View of Packard 120 Engine
Courtesy of Packard Motor Car Company, Detroit, Michigan

whether the water-pump shaft has become rusted and grooved or pitted at the pump where the water-pump packing gland forces the packing against it. If it is rough and badly worn, it should be replaced as it will be impossible to get a water-tight job once the shaft has become roughed up, worn, and rusted away.

Fan Bearings. Inspect the fan bushings or bearings to see whether they are badly worn. Where a roller or ball type bearing is used, it is very seldom necessary to replace them as they are usually adjustable. In many cases bronze bushings are used for bearings at this point and if undue wear has occurred, it is almost impossible to retain grease. When the fan has thrown out all the grease, it will

set up a chattering noise due to slight inequalities of balance. The best plan is to discard the old bushing and install a new one, after which it is fitted to the fan shaft by reaming.

PACKARD 120 ENGINE

The Packard 120 engine is of the L-head type, with the cylinders and upper half of the crank case cast in single-piece form. The

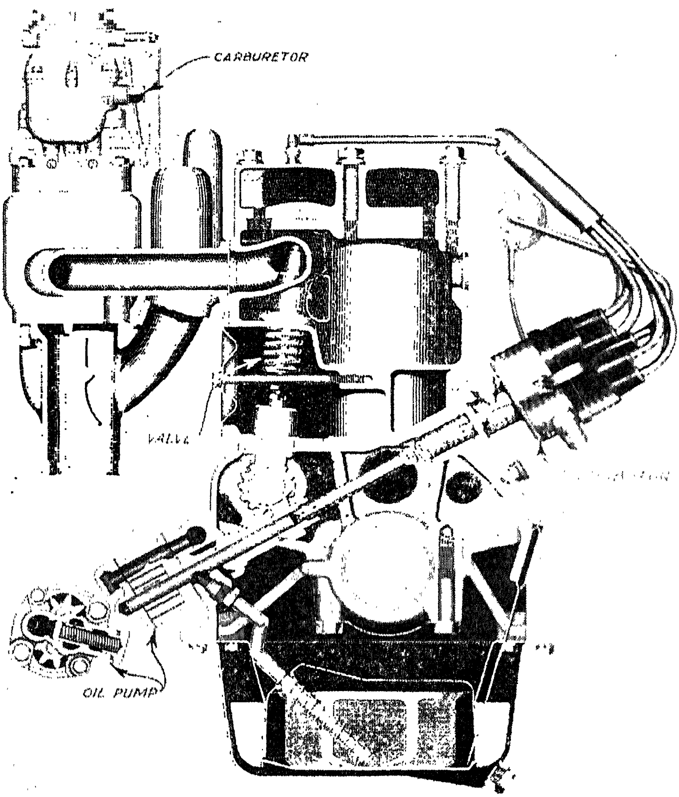


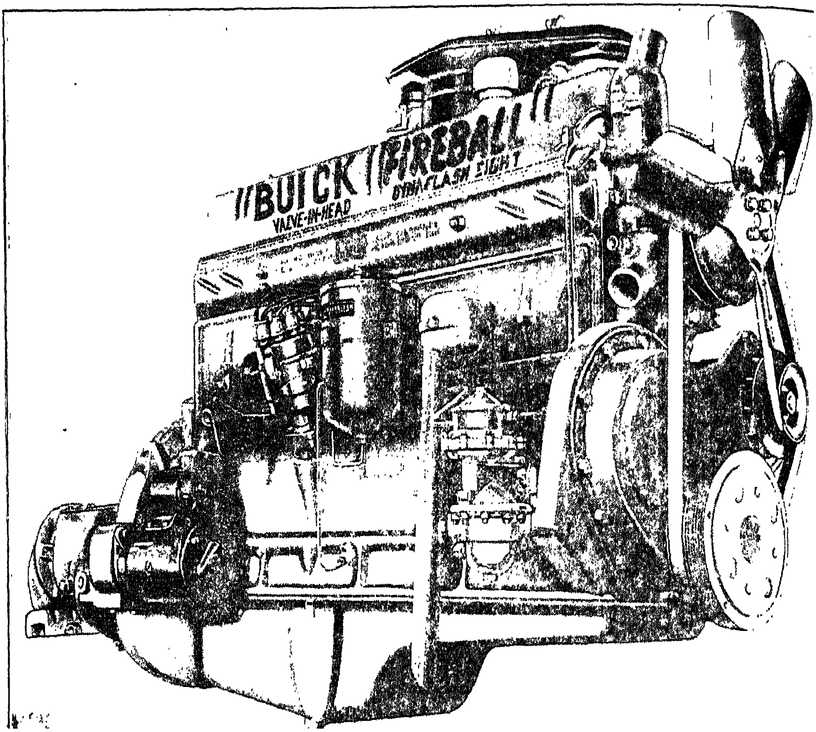
Fig. 18. Front Cross-Sectional View of Packard 120 Engine
Courtesy of Packard Motor Car Company, Detroit, Michigan

aluminum cylinder head is attached to the cylinder block by studs. The valves are of the poppet type and located in the cylinder block. See Fig. 17.

The valves, which are set at an angle to the center line of the cylinder bore, are operated by barrel-type mushroom tappets with adjustment screws for clearance adjustment. See Fig. 18.

The mushroom tappet guides are machined in the block. A silent chain drive is used for the camshaft which operates the fuel pump, oil pump, and distributor. The oil pump is on the outside, on the carburetor side of the engine, with the distributor on the opposite side and with its drive shaft set at an angle across the engine. This is shown in the front sectional view in Fig. 18.

The lubricating system for the engine is very efficient, the oil being under pressure to crankshaft, connecting rod, wrist pins, and camshaft bearings. A jet of oil is sprayed onto the timing chain at intervals. The cylinder walls are lubricated from holes in the connecting rod, and this produces a spray which lubricates the valve lifters.



BUICK FIREBALL DYNAFLASH EIGHT VALVE-IN-HEAD ENGINE, WITH DUAL CARBURETION

Courtesy of the Buick Motor Division, G.M.S.C.

CYLINDERS

CONSTRUCTION OF CYLINDERS

Methods of Classifying Cylinder Forms. Cylinders are classified according to two things, the first of which has to do with the number of cylinders cast together, and the second of which has to do with the form of the head or the general arrangement of the valves. Accordingly we have engines of L-head design, I-head

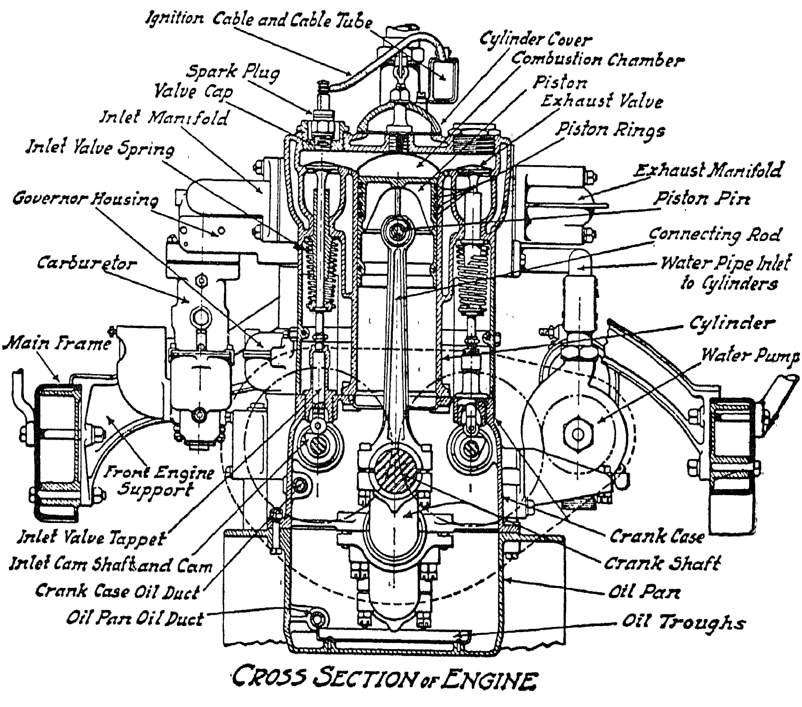


Fig. 2. Section through Typical T-Head Engine
(Note—not in general use in modern cars)

design, T-head design, and F-head design. These letters are used to designate the form of the cylinder as it would appear if the cylinder was sectioned, as indicated in Fig. 1, this being a cross section of an L-head engine.

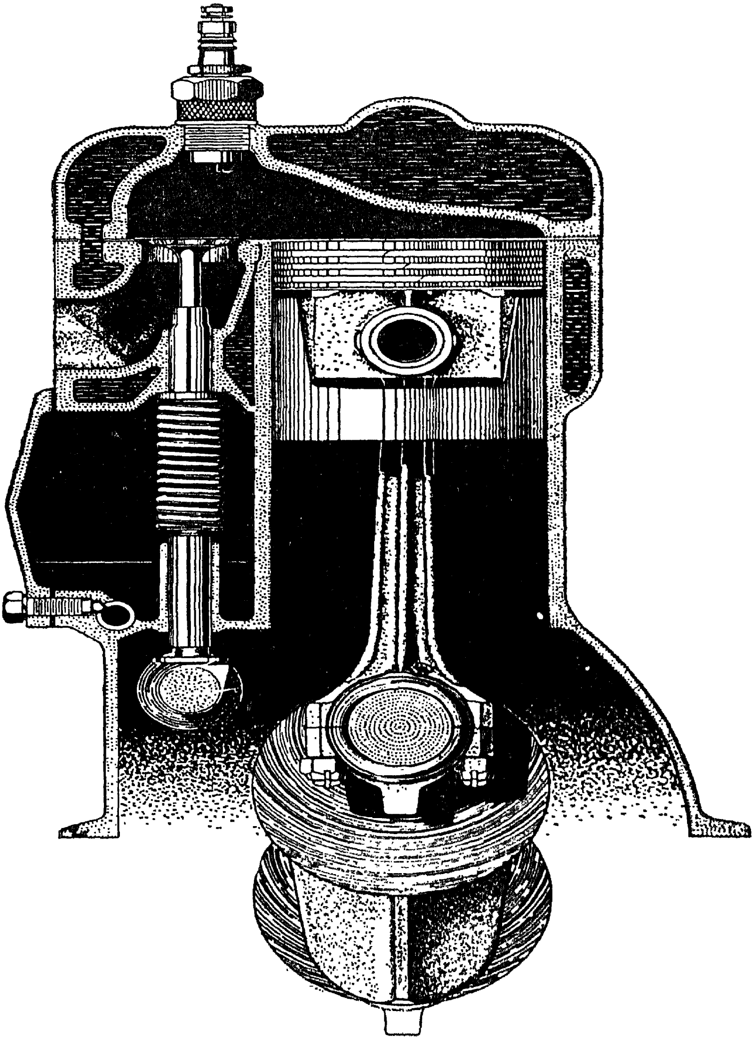


Fig. 1. Section through Ford Model A, L-Head Engine

For some years it has been accepted practice to cast all of the cylinders for a line type engine in one block. This is sometimes spoken of in specifications of motor cars as *en bloc.* The reader will be interested in knowing the S.A.E. (Society Automotive Engineers) nomenclature with reference to cylinder designation.

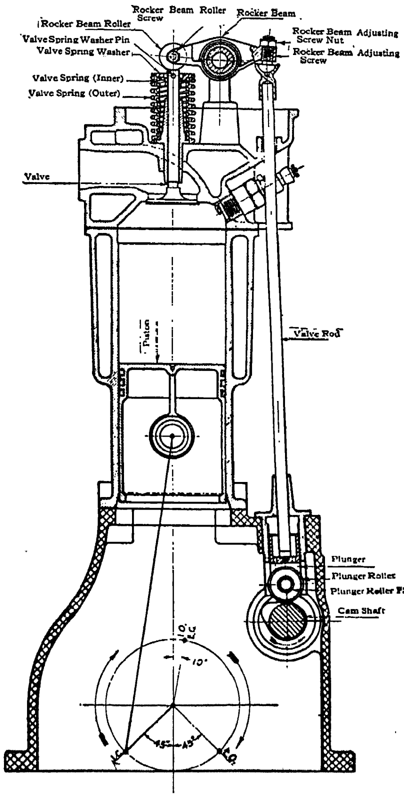


Fig. 3. Section through Typical I-Head Engine

The L-head cylinder has valves on one side of the cylinder block. The T-head engine has the valves on opposite sides of the cylinders and requires two camshafts. The I-head engine carries the valves in the cylinder head, these valves being inverted as compared to the L- or T-head. The F-head engine has one valve at the side and the other one in the head. The side valve is operated directly from a push rod or lifter on the camshaft, and the overhead valve is operated by means of a rocker arm. The Society recommends the use of the term "cast in block" rather than "cast en bloc."

L-Head Engine. This is the most common practice in engine construction. It is, perhaps, the simplest and at once the cheapest in production. L-head engines are quiet in operation and are long lived. Fig. 1 shows the conventional construction of the L-head or, as the English call it, the side-valve engine. It will be noted from this illustration that the valve rests on the valve lifter, which in turn rests on the cam which is integral with the camshaft. The

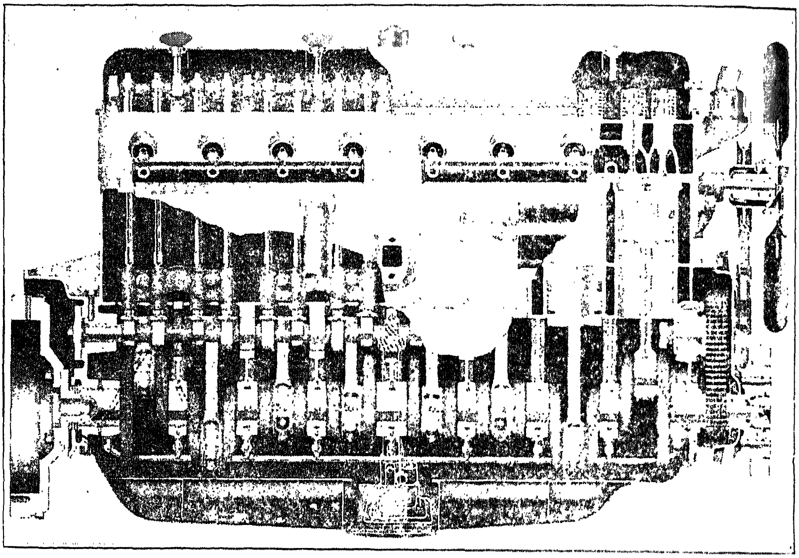


Fig. 4. Sectional View Nash 8 I-Head Engine

cam is driven one turn by the camshaft gear while the crankshaft is turning twice. This holds for all four-cycle engines.

T-Head Engine. This design is more costly as two camshafts are required with the attendant gears or chain and sprocket drive. It is used in some heavy duty trucks and tractors. Fig. 2 shows the cross section of a conventional T-head engine. All exhaust valves are on one side of the engine and all intake valves are on the other side. This arrangement allows room for the use of dual valves, which gives four valves per cylinder instead of two.

I-Head Engine. The I-head engine has long made a strong bid for first place in popularity with the designers and users of motor cars. Undoubtedly it has certain inherent advantages.

The fact that the combustion space is more nearly spherical is an advantage. While most engineers will concede that it is more efficient, the fact remains that more parts are required and these

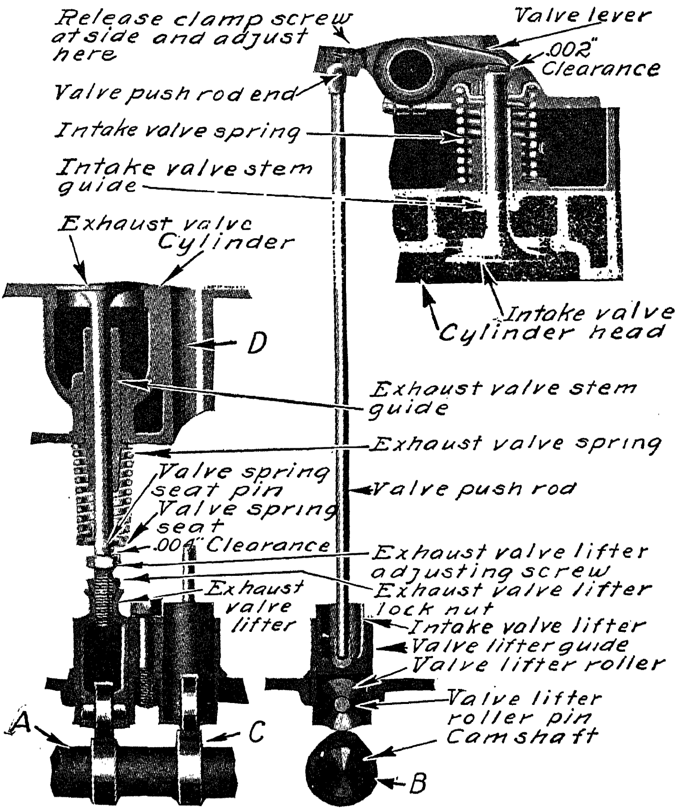


Fig. 5. Typical Valve Operating Mechanism for an F-Head Engine

parts are so placed that they are hard to lubricate properly and keep quiet in operation. The Buick, Nash, and Chevrolet are notable examples of the high degree of refinement which this form of engine design has been brought to. Fig. 3 shows a cross section of a typical I-head engine. It will be noted that the valves are inverted with respect to the position occupied in the L- and T-head engines. In order to operate the valve, which must be pushed down instead of up, the direction of movement of the valve lifter must be reversed. This is accomplished by the addition of a rocker

arm. The line of movement is as follows: The cam lifts the valve lifter and push rod. The push rod raises the outer end of the rocker arm or beam. Thus the inner end of the arm is depressed and the valve is forced downward and open.

The valves are in the center of the cylinder head and are in a row on the center line as will be apparent by a glance at the Nash 8 head in Fig. 4. The valves in cylinder No. 1 are shown in sectioned view and push rods and rocker arms show in the case of rear cylinders.

F-Head Engine. The F-head engine is designed with one valve at the side, similar to the design of the L-head, and with the other overhead as in the I-head engine. Fig. 5 illustrates the F-head valve mechanism. At *A* appears a section of the camshaft with the two valve lifters. The exhaust valve is the side valve and the overhead valve is the intake. The reader will be interested in making a study of this valve mechanism since the names appearing on this illustration are those adopted by the S.A.E. and are those which should be used in speaking of the valve actuating parts and the valves. The parts at *B* have been turned a quarter turn and moved to the side for the sake of the illustration. The cam *C* is the same as *B*, but viewed from the side position. The valve push rod passes through the cylinder casting at *D* when in natural position.

V-Type Engine. The Ford Lincoln-Zephyr V-12 engine used in the Lincoln-Zephyr car is of the V type, with twelve cylinders which are set at an angle of 75 degrees, as shown in Fig. 6. This angle gives a firing impulse of 75 degrees, and 45 degrees of crankshaft travel. The cylinders are offset .250 inch.

The piston is made of a special, heat-treated steel alloy and has two compression rings and one oil ring. The piston pin is of the floating type and the end movement is controlled by retainers in the piston, so that the piston pin will not rub against the cylinder walls. The pin fit is very close, being .0002 inch to .0009 inch in the rod, with a plus or minus allowance of .0001 inch in the piston.

The connecting rods are made of steel forging I-beam sections, which is a strong rigid construction. The connecting-rod bearings are of copper-lead, steel-backed, and are made in halves with no shims between them, which makes the bearings non-adjustable. The total diameter clearance is from .0015 inch to .003 inch.

The crankshaft is of special, hard cast alloy which gives long wearing qualities with little distortion. The cranks or connecting-rod bearings are set at 120 degrees with counterweights cast integral with the shaft. This shaft revolves in copper-lead, steel-backed bearings made in two halves and without shims. The allowable end

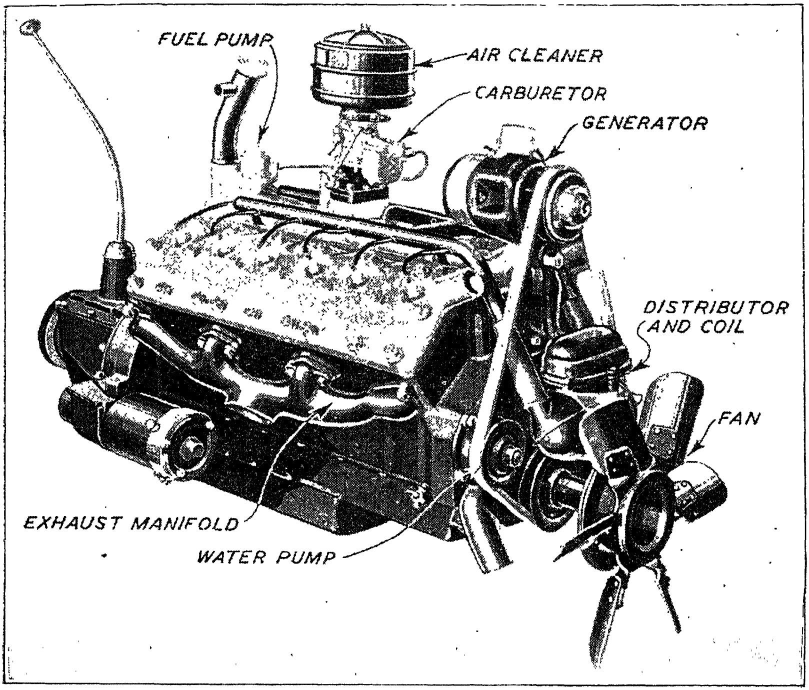


Fig. 6. Lincoln-Zephyr V-12 Engine
Courtesy of Lincoln Motor Company, Detroit, Michigan

play is .002 inch to .006 inch with bearing clearance of .001 inch to .003 inch.

Engine lubrication is of the pressure type to main and connecting rods, and also to the camshaft. The gear type oil pump gives adequate lubrication, pumping more than 1½ gallons per minute at 1000 revolutions per minute.

Engine cooling is by two vaned centrifugal pumps, one for each bank of cylinders. They are driven by belts which also drive the generator. The pump shaft is made of rustless steel. The water

circulation is controlled by thermostats. The firing order starts with No. 1 plug, which is that nearest the radiator in the left bank as seen from the driver's seat, and is 1-2-3-4-5-6-7-8-9-10-11-12, with the odd numbers in the left bank and the even numbers in the right bank of the cylinders.

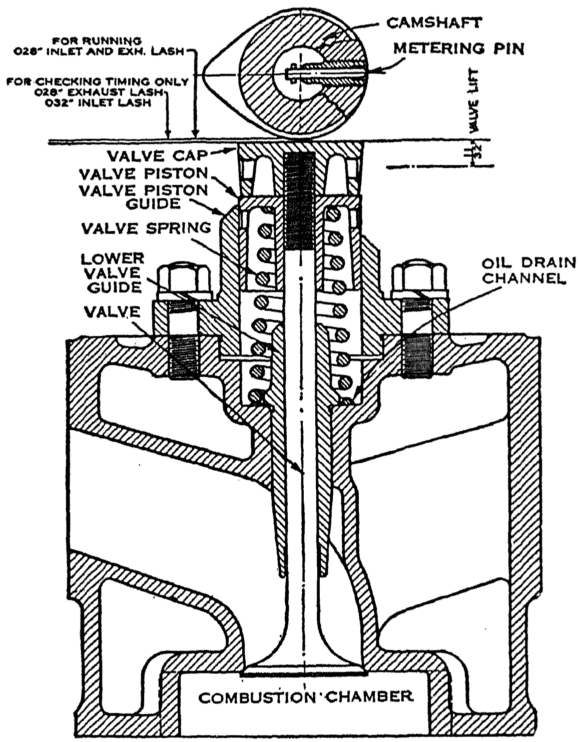


Fig. 7. Cross Section through Valve of Overhead Camshaft Engine

Overhead Camshaft. In some of the foreign countries, the overhead camshaft construction has long been popular. In the United States the tendency has always been toward simplification of moving parts. An outstanding example of the success of the overhead camshaft principle is to be found in the racing engines. Fig. 7 shows a cross section of the valve, camshaft, and cylinder. It will be noted that the camshaft forces the valve down when it comes into contact with the valve piston. This device takes the

side thrust and prevents wear on the valve stem. The camshaft is driven by means of silent chains.

The form of the cylinder casting is affected materially by the design of the valve mechanism. The location and method of actuating the valves also has a definite influence on the shape of the combustion chamber and this in turn on engine performance.

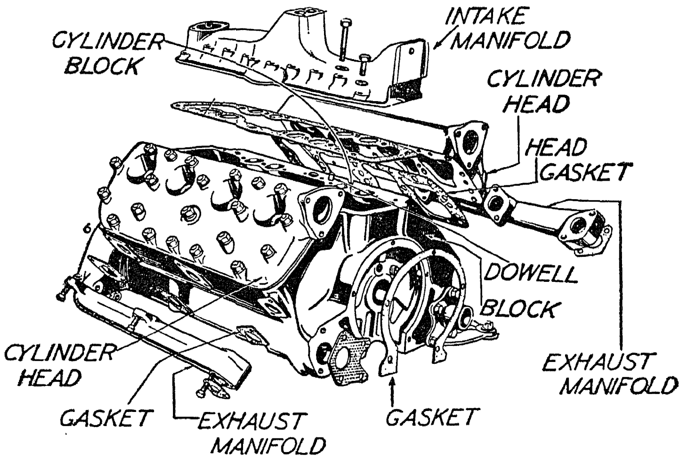


Fig. 9. Ford V-8 Cylinder Block with Related Parts

Methods of Casting Cylinders. The cylinders for automobile engines are cast in blocks, but one block being used for any in-line engine, such as the ordinary 4-, 6-, or 8-cylinder engine. In the case of the V-type eight, two blocks of four cylinders each are used, except in the case of the Ford V-8 which has all cylinders and the upper half of crank case cast integral. The cylinders are cast from gray iron. Some factories use a special alloy of gray iron in order to secure long wearing qualities. Within recent years, some nickel is added in order to insure the proper degree of hardness in engines designed for long service.

In order to provide space for water cooling, the cylinder block is water-jacketed, except the air-cooled engines. This means that a very complicated mold is required for pouring and consequently the patterns for providing the mold, with their attendant core boxes, are very intricate. When engines are cooled, the water circulates from the bottom of the cylinder upward, so that with the re-

movable cylinder heads provision must be made to allow the water to pass from the cylinder block into the water jacket of the cylinder head. Fig. 9.

It can readily be seen that much thought must be given to the placing of fins and ribs so as to secure proper water circulation and at the same time prevent cylinder distortion when the heat caused by the operation of the engine makes itself felt in the expansion of the cylinder metal. All engineers are agreed that cylinder metal will season in much the same fashion that wood will season. In seasoning, the cylinder metal will warp, and cylinder blocks which have been machined when the metal was "green" are very likely to season in service, with the result that the cylinder will not be true.

This condition has a very definite effect on the repair man's job. If he understands what may happen to a new engine when it is being run in, he will be in a position to explain to his customers why it is sometimes necessary to recondition the cylinders on engines which are comparatively new.

Another item which most repair men fully appreciate is the high value placed upon a cylinder block. This one part of the engine is perhaps more valuable than any other single part, since it has had so much machine work in order to complete it and make it ready for service. It also carries, in many instances, the upper half of the crank-case with the upper halves of the main bearing. Consequently, if the cylinder block suffers damage in any form, such as freezing and bursting or fracture from an accident or scoring from loose wrist pins, and should require replacement, it will prove a very expensive project. It is the part of a mechanic to educate his customers to the value of a good cylinder block and methods of proper care of it. It is also his duty to educate his customers to the fact that a cylinder block which has been reconditioned after five thousand or more miles of service is a better cylinder block than it was the day it was turned out.

Pontiac Cylinder Cooling System. In the 1936 Pontiac the water jackets, which surround the cylinder bores, are extended downwards and completely surround the cylinder bores, as shown in Fig. 10, which results in cooler cylinder walls. With this arrangement, all temperatures have been considerably reduced for high speed driving, which keeps the lubrication oil from being thinned out. This insures better lubrication with longer cylinder, piston, and piston-ring life.

If overheating is found on cars with considerable mileage, the water distributing tube, indicated in Fig. 11, should be cleaned of rust and corrosion. The tube is located behind the water pump, and can only be seen after the water pump has been removed.

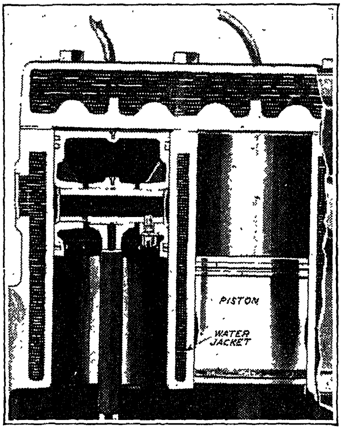


Fig. 10. Pontiac Cylinder Cooling System
Courtesy of Pontiac Motor Company, Pontiac, Michigan

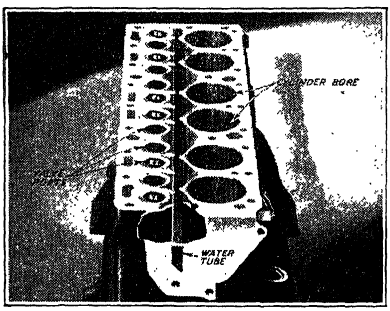


Fig. 11. Pontiac Cooling System for the Valves
Courtesy of Pontiac Motor Company, Pontiac, Michigan

Combustion Chamber Design. Considerable attention is being paid by the engineer to the design of the combustion chamber in the present-type engine. To obtain the best possible efficiency out of the engine, the fuel must burn thoroughly and quickly, and the combustion chamber is designed to this end. The object is to make

the fuel swirl around the chamber and then compress it in a compact mass, Fig. 12, around the plug points. This swirling movement is called turbulence. The rate at which the fuel will burn is directly dependent on the rate of turbulence. There are two effective ways of causing turbulence: (1) a great velocity of incoming gas on the suction stroke; (2) causing the charge to flow on the compression stroke. If the first method is used, there should be no sharp corners in the combustion chamber which would tend to stop the turbulence. The desired effect is best obtained by designing the chamber so that the up-stroke of the piston will cause a rapid movement of the charge. Fig. 13 shows a spherical-shaped combustion chamber used to promote a swirling motion. As the piston rises, it will cause the fuel to swirl in a circular motion. Fig. 14 shows several designs which will cause the gas to be greatly agitated and compressed into a very dense mass around the spark plug points when it is in the best possible shape for ig-

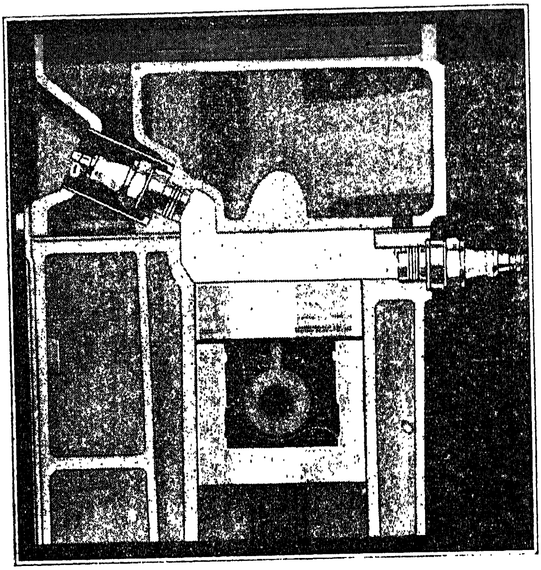


Fig. 12. Combustion in Process in Nash Overhead Valve Twin Ignition Engine Cylinder

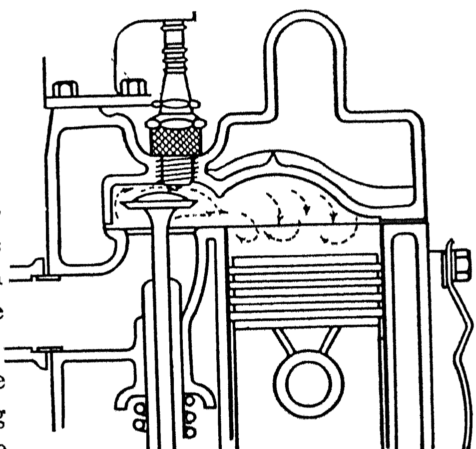


Fig. 13. Turbulence Combustion Chambers

nition. In these designs there is a great amount of space directly over the valves, but very little space over the piston on top dead center. A good design in which the swirling motion produced is indicated is shown in Fig. 13. The gas should obtain a great amount of velocity in this design and, of course, it would be greatest at the end of the stroke. The gas is highly compressed when ignition takes place.

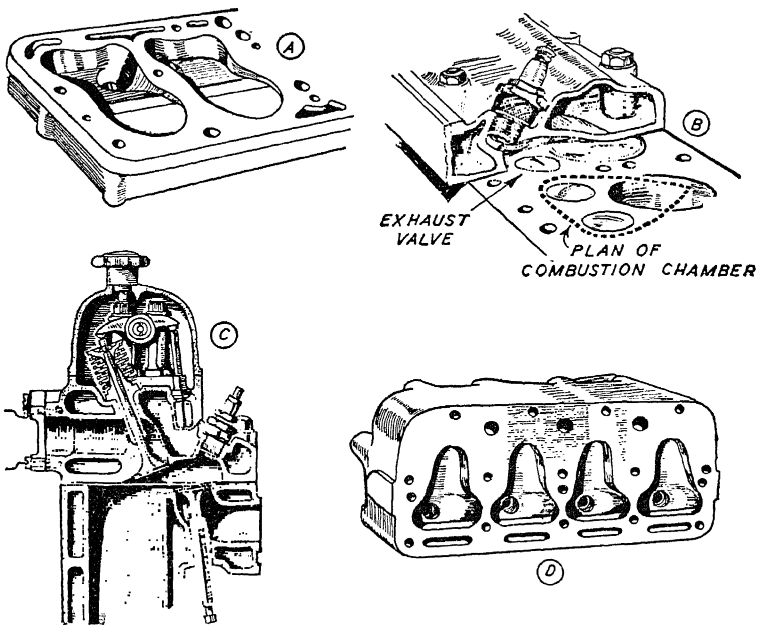


Fig. 14. Cylinder Heads are Designed to Promote Turbulence and Decrease Pinging. A—Head With Ricardo Characteristics; B—Heart Shaped Combustion Chamber; C—Head Engine; D—Turbulence Producing Design.

Spark Plug Position. The position of the spark plug is important. It should be placed where it can be kept as cool as possible and where no dead exhaust gases can accumulate. In cylinders where a turbulence is obtained and where the exhaust and intake ports are open to each other, the plug position should be out of the path of the oil thrown up by the piston and away from the wet incoming gases which are found at the time of starting. The plugs should also be as close to the center of the gases as possible.

Water Jackets. The water jackets around the cylinders should be of ample capacity in order to give uniform cooling and eliminate

steam pockets. The water should enter at the bottom and be free to flow to the top. Its temperature is increased as it comes in contact with the hotter parts of the cylinder. It is a distinct advantage to have ample cooling around the valves and spark plugs. This prevents the valve from warping and the spark-plug electrodes from getting red hot, causing preignition.

CYLINDER TROUBLES

Warping. If the cylinder casting is not heat-treated correctly, it will warp in service. Heat treatment relieves the internal strains in the casting, and some manufacturers season the casting by leaving them out in the weather. This method is considered by many to be the best treatment because it is a natural one. The only cure for warping is to refinish the bore of the cylinder. In the rush of production, a bad cylinder block will often pass inspection. An engine that pumps oil in the early part of its service may show signs of warping if the cylinder bore is measured closely.

Scored Cylinders. This is caused by several things, and in most cases can only be cured by regrinding or reboring. If the score is light, it can often be lapped out, but in any case new pistons must be fitted.

A cylinder that is scored or worn will cause the engine to run unevenly and also cause a loss of compression. A hissing noise in the crankcase is an indication of this trouble. In testing, place a piece of rubber hose on the breather pipe or at the point where the oil is poured into the crankcase. Place the other end to the ear and the hissing noise can be heard distinctly. To find the cylinder which is actually faulty the engine must be disassembled for inspection and measurement.

CYLINDER REPAIRS

There are a number of things which may happen to a cylinder causing it to become faulty and in the need of repairs. The prime purpose served by the cylinder is that of receiving the gases from the carburetor and serving as a place in which the gas and air may be compressed and fired without loss of compression. If the cylinder has been worn by the piston or by the rings until it is no longer true or if it has become too large for the piston or if there is a piston

pin or other score, it will fail of performing its duty satisfactorily. An engine which is allowed to overheat may have the cylinder warped or scored. An engine which has been in a wreck may have the cylinder damaged due to fracture of parts or straining of parts. An engine which has been frozen may have the cylinder walls sprung out of round, the walls cracked, or the water jacket damaged. All of these faults need service work in the garage to repair them. Generally speaking, the cylinder faults requiring the most work are those which have to do with the cylinder bore, which needs to be reconditioned. The cylinder bore which is in perfect condition is the one which is truly cylindrical and is square with the crankshaft or the cylinder face which is supposed to be true and parallel with reference to the crankshaft. The service man then looks for piston ring or piston pin scores, out of roundness, taper, high spots, out of square, and similar faults, when the customer makes complaint about loss of compression. These are the things which may be wrong with the cylinder. There are many which may be wrong with the piston, valves, gaskets, etc., and they must be sought out, as explained in the sections dealing with those parts or units.

LOCATING CYLINDER FAULTS

Visual Inspection. A fault in the cylinder may be detected by turning the engine over by hand and similar methods. These only indicate trouble, however, and do not show what the trouble is. In order to find the trouble, it is usually necessary to make a visual inspection by removing the cylinder head and then turning the pistons to the bottom of the stroke. This will show up any items, such as the piston pin scores showing in cylinders No. 3 and 5, Fig. 15, which is an unretouched photo of a block which came into the shop for repairs.

When the oil fails for any reason, trouble similar to that appearing with the piston at the left of Fig. 16 is likely to be the result. This piston is badly scored and the cylinder is usually scored almost as badly as the piston when this sort of thing happens.

Whether caused by piston, piston pin, piston rings, or heat and lack of oil, a cylinder which has been scored must be reconditioned. Methods of doing this work are given at the latter part of the chapter.

Not all cylinders which are in bad condition show scores. They may be just as "smooth as glass" but still be far from perfect. Precision measuring tools are needed to show up this condition.

Accurate Measuring Tools. Automobiles are not built in any haphazard way, nor can they be repaired in any such fashion with

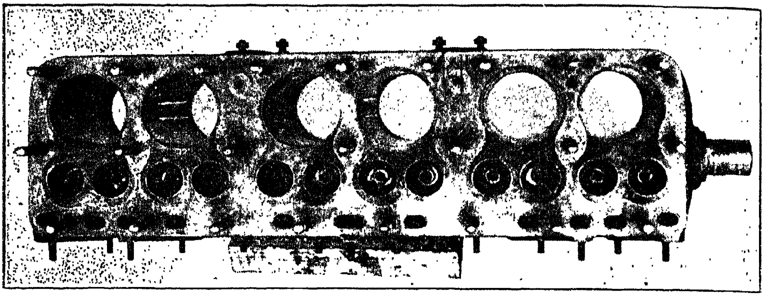


Fig. 15. Cylinders 3 and 5 of This Block Were Scored by Loose Piston Pins

Fig. 16. The Piston at the Left Was Scored, Due to Oil Line Failure; the Cylinder Was Scored as Badly as the Piston
The Piston at the Right Is a "Good" One from the Same Engine

the assurance that a good sound and flourishing business may be built on the process. Whether the mechanic is working for himself or for an employer makes no difference in the final analysis. Money must be earned before it may be paid out as wages and profits.

The most accurate measuring devices in the world are owned by the automobile manufacturers. Henry Ford has in his possession at the factory a set of blocks, known as the "Johansson Gauges," which are accurate to very fine limits. Some would-be mechanics persistently refuse to learn how to use precision measur-

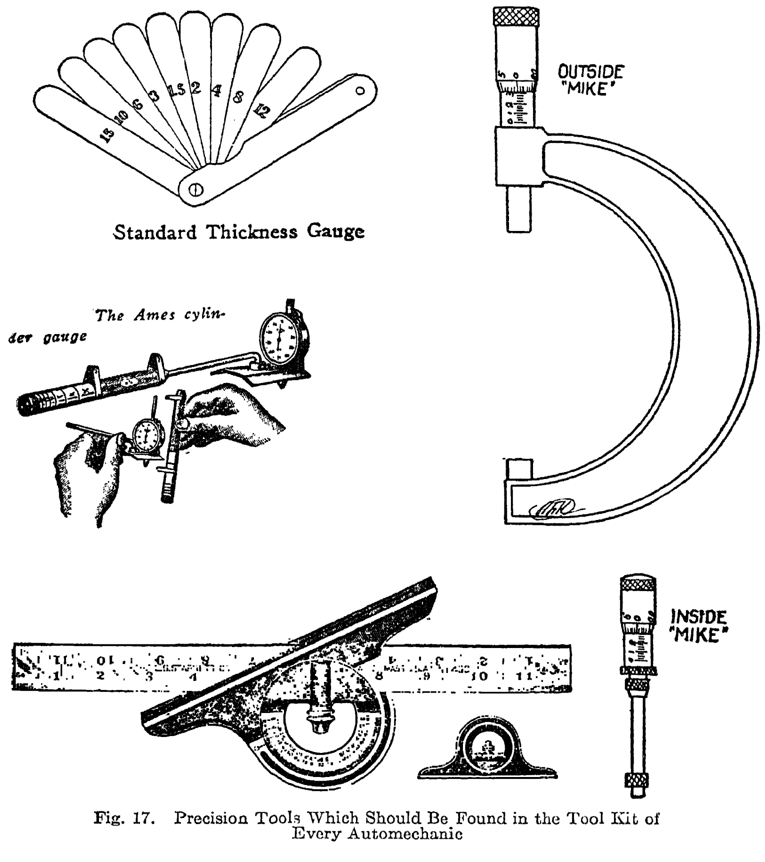


Fig. 17. Precision Tools Which Should Be Found in the Tool Kit of Every Automechanic

ing tools such as are illustrated in Fig. 17. At the bottom of this view appears the combination square and rule. This device will allow the workman to lay out to very fine limits the degrees of any desired angle or it will serve as a check-up on any angle already at hand. The rule is removable and serves as an accurate measur-

ing device when working to limits of not less than one-sixty-fourth inch. Some of these combination squares also have a head in which there is a level. These are very valuable in the shop for setting up work on a machine, such as the drill press or shaper.

The inside and the outside calipers should be in the kit of every mechanic. These with the divider form a group of measuring and marking tools which are in constant demand. They are not illustrated. The outside micrometer, commonly termed "mike" around the shop, is the only absolutely dependable tool to use when measuring for exact dimensions. When the micrometer is set to the work to be measured, the result is read direct on the thimble of the handle. There is quite a little trick in reading the mike, but it can be mastered by any earnest mechanic. Then when he measures a piston, he can know exactly the size, even down to less than one-thousandth part of an inch.

The outside micrometers are used in measuring all round stock or parts. The inside micrometers are used in measuring all items such as cylinder bores. The inside mike is read direct from the thimble on the handle just as is the outside mike.

Another tool designed to make the work of the auto mechanic of high standard is the cylinder gauge. This is a device made so that it may be inserted into the cylinder and then moved up and down and the variation in diameter of the bore read or noted on the dial gauge. The handle of the one shown is provided with a device which permits the mechanic to check up and learn the exact reading in thousandths of inches.

A thickness gauge is to be found in the tool kit of every automechanic. In fact, it is generally carried in the pocket so frequently is it called into use for checking clearances.

Checking a Cylinder with the Feeler Strip or Gauge. The Oldsmobile Co. has improved the wearing qualities of pistons in the 1936 cars by giving the piston the sulphuric oxalic acid treatment. This process leaves a hard film on the wearing parts of the piston. The piston-pin hole is made slightly smaller on the lock-screw side of the piston, which gives a snug fit on this side, and allows for contraction and expansion in the opposite side.

The skirt of the piston is oval in shape, with the greatest diameter at right angles to the piston-pin hole diameter. When fitting

pistons in the six-cylinder engine, the diameter of the pin holes should be .007 inch to .009 inch smaller than the diameter at right angles to the piston-pin holes, or the thrust side. On the eight-cylinder engine,

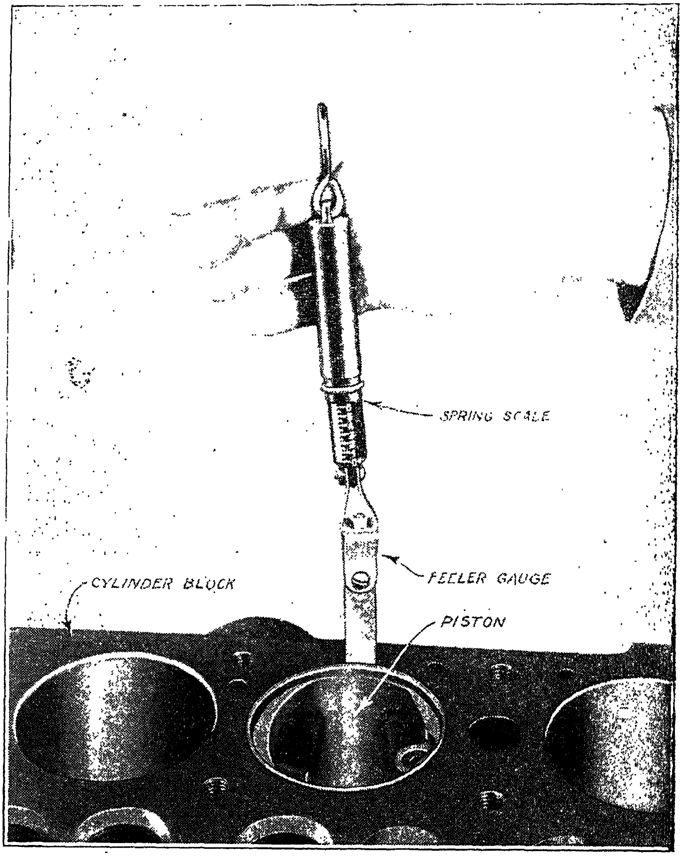


Fig. 18. Testing Piston Clearance
Courtesy of Olds Motor Works, Lansing, Michigan

it should be .006 inch to .008 inch smaller at the pin hole diameter than on the thrust side diameter.

In replacing pistons, those in the six-cylinder engine can only be removed through the top of the cylinder bore. Those in the eight-cylinder engine are removed at the bottom of the block by rotating the crankshaft so that the counterweights are toward the opposite side of the crankcase to that of the camshaft.

When fitting pistons to cylinder bores, a feeler gauge, half an inch wide by twelve inches long and .002 inch thick, is used between the thrust surface of the piston and the cylinder wall. Fig. 18 shows a feeler gauge in use. The clearance between the maximum thrust side and the cylinder wall should be .0013 inch to .0018 inch with the

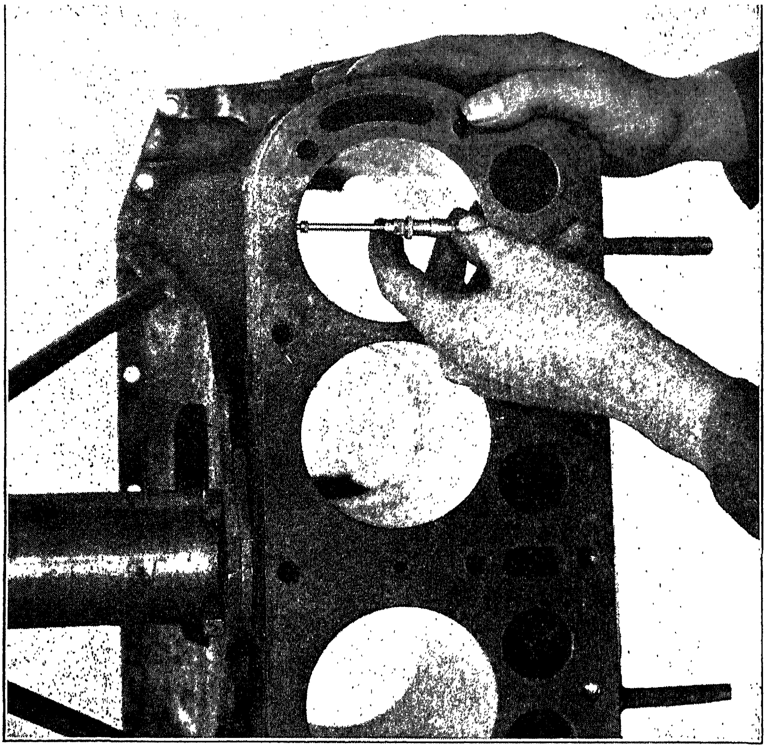


Fig. 19. · Using the Inside Micrometer to Determine Amount of Out-of-Roundness, Taper, Wear, or Oversize
The size is read direct on the thimble of the handle.

cylinder and piston at normal room temperature of 70 degrees. With a spring scale attached to the end of the feeler gauge, as shown in Fig. 18, it should take between four and eleven pounds' pull on the scale to pull the gauge out from between the piston and cylinder wall. It is not always possible to have the parts at 70 degrees, and where temperatures are lower the pounds' pull will be towards the lower end of the limit allowed. For higher temperatures it would be

towards the higher pull limit allowance. This variation allows for the expansion and contraction of the pistons. Each piston should be fitted to an individual cylinder bore and so marked. Pistons are installed

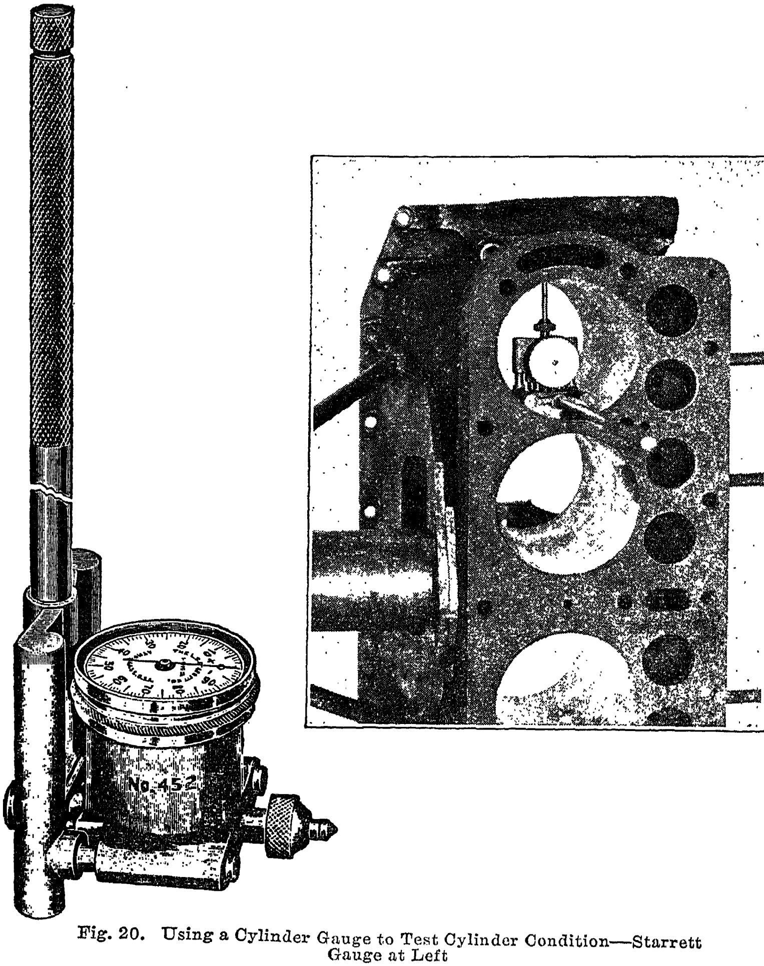


Fig. 20. Using a Cylinder Gauge to Test Cylinder Condition—Starrett Gauge at Left

with the mark "V-S" on the top, placed toward the valve side of the engine.

Testing a Cylinder with Inside Micrometer. Fig. 19 shows how the inside micrometer is used to determine the cylinder condition. The cylinder should be "read" at the top, center and bot-

tom, at the point shown, that is, across the block; and then it should be read at these three points in line with the block so as to have the variations indicated. As a rule, the diameter across the block will be greater than with the block. Also a taper is very likely to show, the general rule being that cylinders show more wear at the top than at the bottom.

Testing the Condition of a Cylinder with the Cylinder Gauge. Insert the cylinder gauge as shown, Fig. 20, and set the dial to read zero. Now move the gauge downward into the cylinder. Any variation means that there is a taper and it is likely that the cylinder will be smaller at the bottom. The number of graduations on the gauge is the amount of variation and it may be read as .003− or .003+ as the case may be.

Next, remove the gauge and insert it across the cylinder. Use care not to move the dial. Any reading other than zero when measured at the top of the cylinder indicates that the cylinder is out of round and the variation may be noted and recorded as plus or minus so many thousandths of an inch.

REMEDYING CYLINDER FAULTS

Reconditioning Cylinders by Honing. This practice is generally accepted by the service managers of all factories as being the most readily adapted for the service station. When it is desired to grind out small scores or to refinish the cylinders to an oversize, the hone will do it quickly.

The hone, Fig. 21, is typical of good hone design. This device is made to revolve within the cylinders either by an electric drill or by a drill-press, and as it revolves it is passed upward and downward through the cylinder. The stones are cemented into steel channels, eliminating any trouble with stone breakage. The fabric guides, alternating with the stones, permit of a finer finish as well as faster cutting.

The internal construction of the device insures the pressure being equal at all times. Consequently the cylinder is ground true, giving a perfectly round and parallel cylinder.

The cylinder hone should be run wet or dry as preferred. It should be lubricated with a mixture of one-half cylinder oil and one-half kerosene when used wet. When run dry, protect the engine

parts by using the Hono Vac supplied by the builders of the hone. After a period of service the pores in the stone become filled with iron and in order to eliminate this, special rubbing stones must be used to remove the particles of iron if fast cutting is required. Use care in eliminating taper and ridges left by ring travel.

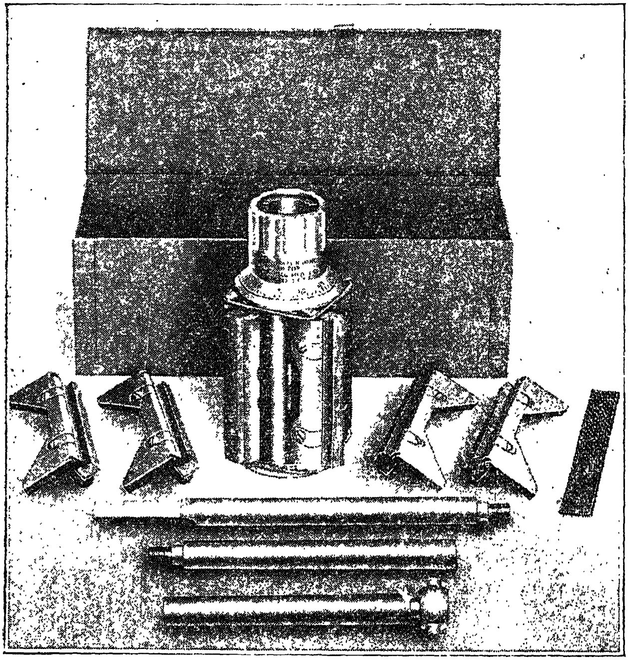


Fig. 21. Cylinder Hone with Extra Stone Cutters
Courtesy of The Hall Manufacturing Company, Toledo, Ohio

One advantage with this type of finishing is that it is unnecessary to remove the cylinder block from the car consequently a quicker repair can be made to any engine. The device generates a cylinder bore and eliminates a good deal of the wear which usually takes place in cylinders which have been finished by the reboring or regrinding method, because there are no ridges to wear away in the first few hundred miles of running, thereby giving a longer service because of less wear.

Fig. 22 illustrates the use of the hone in refinishing a cylinder

to size for a set of oversize pistons. In doing this work it is advisable to have the cylinder gauge at hand to check up on the cylinder bore to see that the work is progressing in proper manner. It will show up any taper or out-of-roundness so that the mechanic may work at the proper point to correct the fault. Without it, it might be that the cylinder would be ground bell mouthed at the lower portion before the piston would start to enter at the top.

There are several methods of using a hone. One is to hold

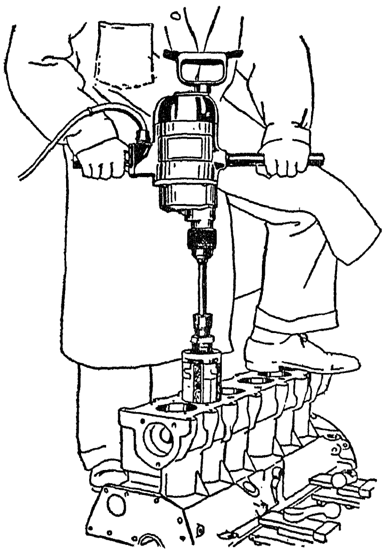


Fig. 22. Honing Cylinders

the hone with the half-inch heavy-duty electric drill or with the five-eighths-inch drill and use the arms and body to raise it and lower it. If the hone is of the positive set type, this is satisfactory as the hone is kept set up so that the stones are cutting at a rapid rate at all times—that is, just as quickly as the stones have cut away enough cylinder metal to allow the drill to bring the hone up to its best speed, the drill is shut off and the hone reset for another cut. This means that there is a minimum amount of lifting of the drill. There is quite a decided pull or torque on the drill when the hone is cutting heavily. The mechanic appreciates this as

evidence of the cut being made. As this torque or pull is lessened, it is a sign that the cut is being finished and the hone may be set up again.

Another method of handling the weight of the hone and heavy drill is to use a long coil spring and support it overhead. The weight is balanced by the spring and the workman is thus relieved of much of the heavy work.

THINGS TO REMEMBER WHEN HONING CYLINDERS

Have the hone in good condition, with the stones clean and true.

Have the proper grade of stone—coarse for removing metal, fine for finishing.

Have the drill or electric drill in good condition. Do not use a light powered drill or it will be burned out.

Place the work in a convenient position. If possible, use a pan under the work to catch the kerosene.

Use plenty of kerosene to flush away the cuttings and keep stones clean.

If the work is done "in the car," protect the crankshaft and engine bearings from the grit by means of carefully placed clean rags, or a can or other oil catcher under the cylinder being conditioned.

Check the cylinder continuously to insure proper work. Use a cylinder gauge, an inside micrometer or the piston, and a feeler strip.

Fit each piston to its cylinder and mark so as to prevent mixing.

If the hone is working properly, it will be possible to complete four to six bores in from one to two hours.

Watch out for "bell mouth," taper, or out-of-roundness. Mix a liberal amount of "brains" with the "elbow grease."

Use an electric drill oı ample power.

Keep the hone moving through the cylinder bore, up and down, while it is rotated by the drill.

Clean the job thoroughly after the cylinders are brought to size.

Grinding Cylinders with Cylinder Grinder. There may be some cause for misunderstanding among those who enter the automobile work as to what cylinder grinding is. In the older sense of meaning of the term, all cylinder grinding was done on grinders on the order of the cylinder grinder shown in Fig. 23. This is a large machine such as is used in factories and in cylinder grinding shops. The one shown is the Heald grinder. The Landis is also a popular machine for this work.

Some hone manufacturers also class their devices as grinders, because they are designed to cut away considerable amounts of cylinder metal in a little while. Possibly both are worthy of the term "grinding," but the smaller device has long been known as a

hone to the trade and the work it does as honing. Most garagemen make this distinction. When they think of a job of cylinder grinding, they are thinking of the job such as that illustrated in Fig. 23.

There are also some portable machines which are designed to be mounted on the cylinder block and they remove metal somewhat after the fashion of the Heald grinder, with a grinding wheel.

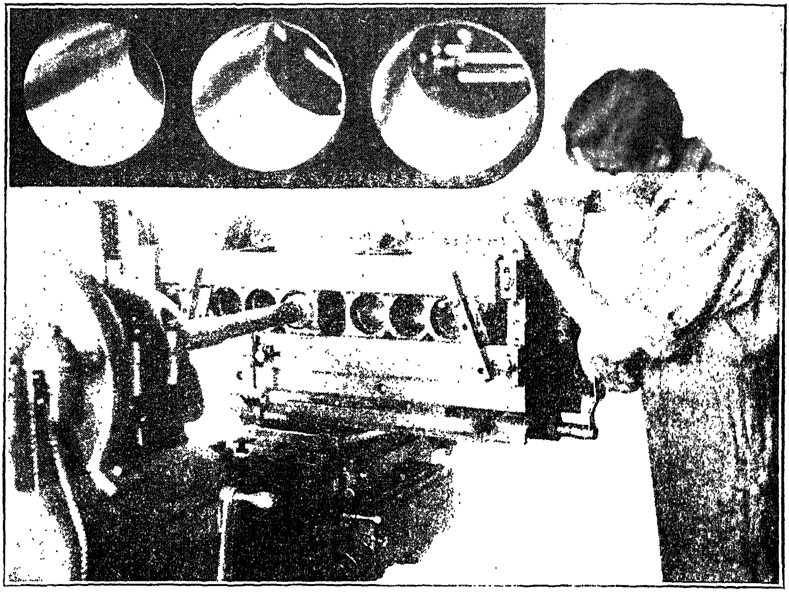


Fig. 23. A Six-Cylinder Block Set Up on a Heald Cylinder Grinder, with the Grinding Operation in Progress on No. 3
The inset at the top shows how the cylinders looked after the work was completed.

The disadvantage of a hone or a reamer or any cylinder reconditioning tool which is set up according to the old bore of the cylinders is one of alignment with the perpendicular from the crankshaft axis. In other words, the bore of an old cylinder block may not be square with the crankshaft. This fact is proven time and again when the used blocks are put on an accurate machine such as shown in Fig. 23. It may be that half or more of the bores will "clean up" with the removal of .010 inch of wall metal. Then a cylinder will be found which is not "square" with the face of the cylinder block and the crankshaft axis. This cylinder, the bore

of which is slightly angular with the perpendicular line will require possibly .020 to .030 inch of wall metal to be removed to give a perfect job. The hone or other device which depends on the old bore for alignment would never correct this fault.

A perfect bore may be generated, but with reference to being square with the crankshaft it is a faulty job and will cause rapid wear on the piston and rings and possibly set up noises in the engine which cannot be eliminated readily. For this reason it is well to test the cylinder bores with the square before determining how to refinish the bore.

The principle on which the cylinder grinder works is rather simple. The spindle which carries the grinding wheel is driven about 7000 r.p.m. (revolutions per minute). This spindle is carried in a grinder head which is so arranged that by turning an eccentric arrangement the grinder spindle may be set off center. The grinder head is made to turn at a much slower rate, about 60 r.p.m. Thus the grinder wheel while being smaller than the cylinder bore is swung on its spindle in a circle which is just large enough to touch all portions of the cylinder wall, or such portions as may be high or out of round.

Now while the spindle and wheel are turning at 7000 r.p.m. and the head is turning at about 60 r.p.m., the cylinder which has been mounted on the adjustable work table and angle plate is fed forth and back over the wheel. Once set up, the action is automatic. The table carries the cylinder forward over the wheel and then automatically reverses and draws it back over the wheel. As the work proceeds, the mechanic adjusts the eccentric arrangement to continue the cutting.

Boring Cylinders. This is perhaps the oldest form of cylinder generation. In fact, the cylinder is called a cylinder bore. The engine lathe was originally used to machine the cylinder. It was bored out just as any other piece of lathe work having an internal bore was produced. This practice is confined to small work or experimental work in the factories. All production work in the factories is done on special machinery, which reams, bores, grinds, or hones, as the case may be.

Fig. 24 shows a boring tool in position on the cylinder block and in it. This machine is designed to bore the hole square with the

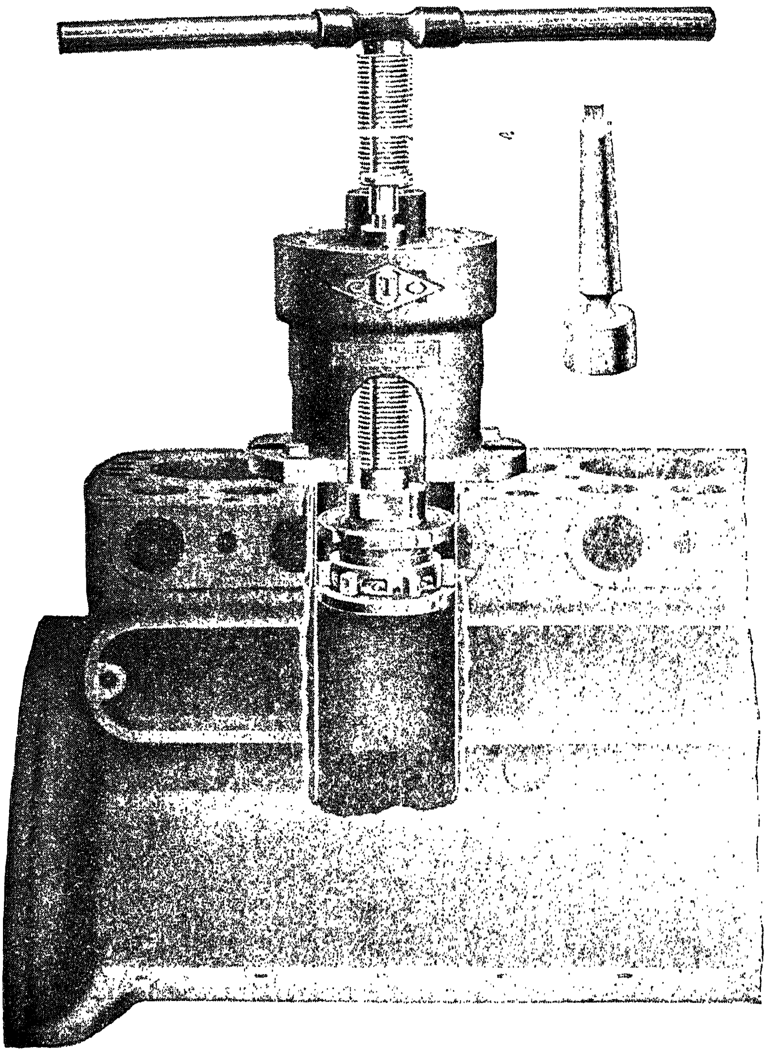


Fig. 24. Boring Tool
Courtesy of Universal Tool Company

face of the block. It is hand operated. Fig. 25 shows the use of a micrometer in setting the blades of the Universal boring cutter. These blades are set accurately and bore the cylinders to this predetermined size. As the work proceeds, the handle being turned, the cutting head is fed down through the cylinder at a fixed rate.

As a rule, boring tools finish the cylinder to the proper oversize in one cut. The cylinder metal is cut away in chips. The new "bore" will be somewhat rough, but unless hard spots are encountered it will be fairly true.

In many shops the hone is used to smooth up the new bores after the cylinders have been ground, reamed, or bored.

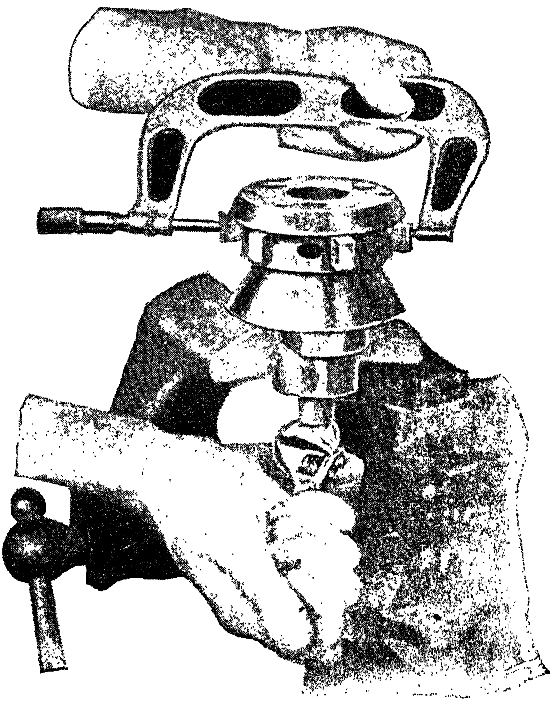


Fig. 25. Setting Cutters with Micrometer
Courtesy of Universal Tool Company

Reaming Cylinders. The practice of reaming cylinders is a common one in the factories. It is also followed in the service repair shops to some extent. It is a rather difficult piece of work, the power being man power applied to the long reamer handles.

The Foster-Johnston reamer shown in Fig. 26 has long been popular in garages for finishing Chevrolet blocks. It is made to fit any size cylinder. If the block is out of the car, the work is done with two men turning the handles around the block, which is se-

curely held. If the work is done in the car, a ratchet handle is used since the handle may not make a full turn. See Fig. 27.

Oversizes Recommended for Cylinders. The S.A.E. recommendations for standard oversizes in finishing up pistons for the replacement business are .005″, .010″, .015″, .020″, .030″, .040″, and in multiples of ten thousandths upward. Naturally this recom-

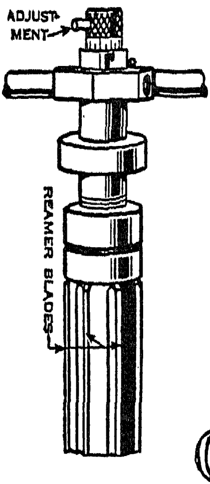


Fig. 26. The Foster-Johnston Cylinder Reamer

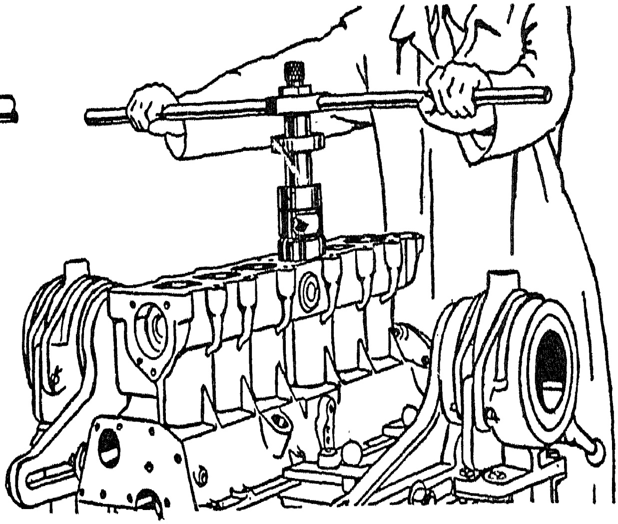


Fig. 27. Reaming Cylinder

mendation has its influence on the pistons available and the repairmen will do well to hold them in mind when refinishing cylinders oversize. Remember, also, that the piston oversize and the cylinder oversize are not the same. There is the piston clearance to be taken into consideration.

Valve Seats. The reconditioning of valve seats in the cylinder block will be treated in the chapter on "Valves."

CYLINDERS

CHRYSLER CYLINDER HEAD

In Fig. 1 is shown the cylinder head of a Chrysler engine. Attention is called to the correct order in which the cylinder head bolts should be tightened.

In Fig. 2 is shown a special wrench that is used to tighten down the cylinder heads or nuts. With this wrench each bolt can be

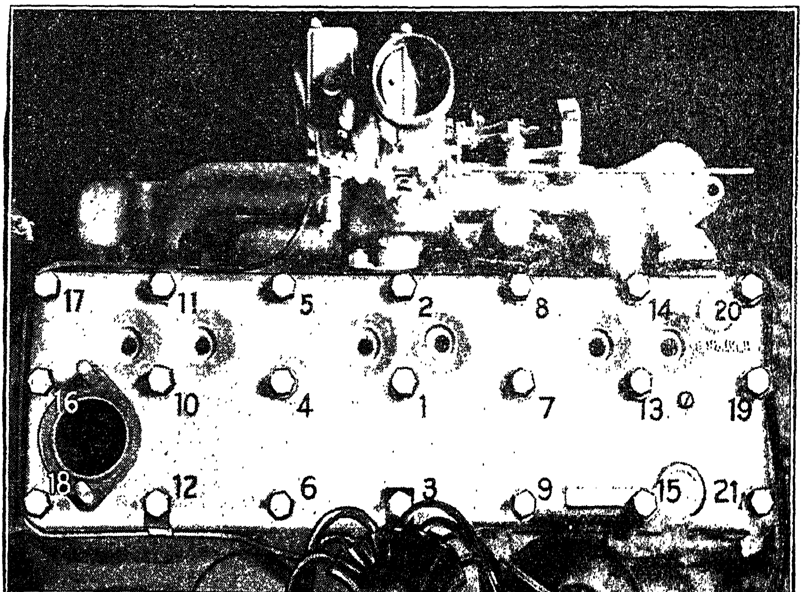


Fig. 1. Chrysler Cylinder Showing Order in which Cylinder Head Bolts or Stud Nuts Should Be Tightened
Courtesy of Chrysler Corporation

tightened to the same tension insuring evenly compressed cylinder head gaskets, thus preventing blown gaskets and also making it easier to get compression tight joints. The wrench prevents overstressing the bolts or studs. Overstressing often causes bolts or studs to stretch and weaken, and it also causes stripped threads or broken bolts and studs in the cylinder block.

On the dial of this wrench are markings, and a pointer moving over the dial and markings shows exactly how many pounds pressure is being put on the studs, nuts, or bolts.

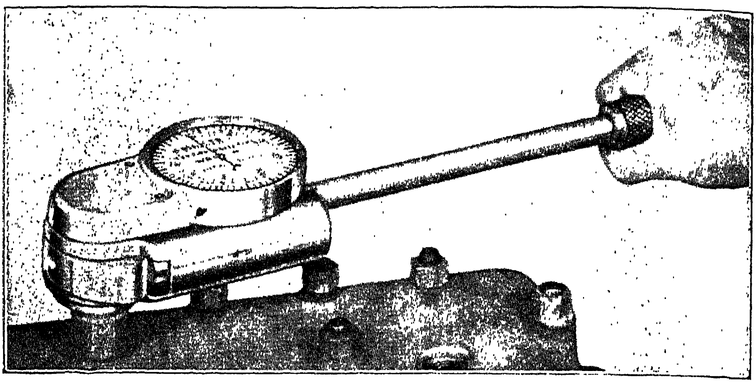


Fig. 2 Special Wrench for Tightening Cylinder Heads or Nuts
Courtesy of Miller Tool Manufacturing Co., Detroit, Michigan

CYLINDERS

CADILLAC-LASALLE ENGINE

In order to increase cylinder bore durability and provide better oil economy, Cadillac-LaSalle introduced a new piston ring arrangement for the V-8 engines of 1939. The piston top land is wider in order to move the top compression ring farther from the heat of combustion. The top ring has been reduced in width to 3/32 inch,

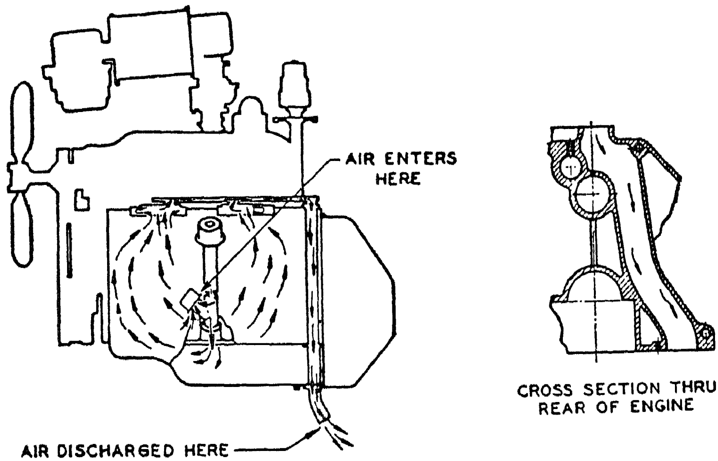


Fig. 1. 1939 Cadillac-LaSalle Engine Ventilating System
Courtesy of Cadillac Motor Car Division, G.M.S.C.

being somewhat deeper, which tends to increase its pressure. All rings are coated with ferric-oxide, which provides longer wear and less possibility of scuffing, especially during the "running in" process of the engine. The same treatment of ferric-oxide is utilized in order to provide greater resistance against scuffing and scoring in the case of the valve lifter bodies. No valve grinding slots have been provided in the valve heads, so that it is necessary to make use of a vacuum cup attachment when grinding valves.

The 1939 V-8 series makes use of a new system of engine ventilation. In this case the forward motion of the car through the atmosphere creates a suction which is used to draw the gases from

the crankcase instead of using the engine suction. As illustrated in Fig. 1, most of these parts required in the design are integral with the engine. In operation, air enters a screened opening in the oil filler pipe, and after ventilating the crankcase, passes upward into the valve tappet compartment, after which the gases pass back into a cored passageway between the engine rear bulkhead and the flywheel. From that point the gases pass off beneath the car through an outlet fitting which is a part of the oil pan.

The oil pan sump for the 1939 V-8 engines is shorter and deeper than before. This arrangement tends to concentrate the oil supply so as to reduce aeration of the oil under any and all conditions. This is especially true when the pan is slightly over-filled.

PISTONS, PISTON PINS, AND PISTON RINGS

Piston Construction. The pistons in the Buick engine are of lightweight alloy, and are heat treated. After being finished to size, they are given the "anodic" treatment. This treatment is electrolytic in nature and oxidizes the surface of the piston, leaving it

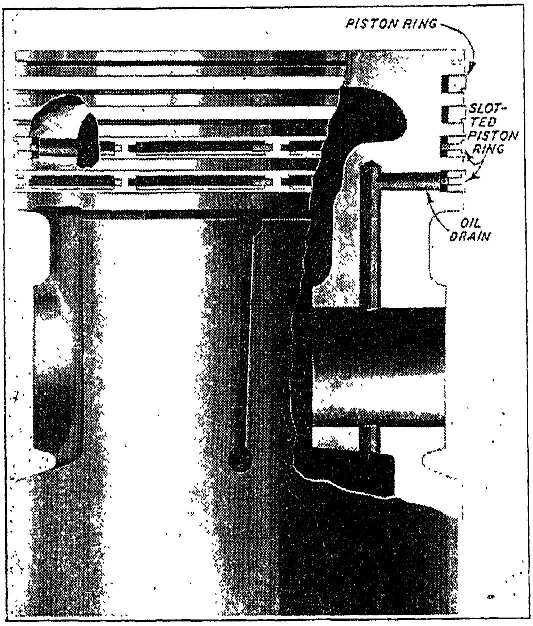


Fig. 1. Showing Buick Piston Construction
Courtesy of Buick Motor Company, Flint, Michigan

very hard and slightly porous, which greatly resists wear. Oil adheres to the surface so that the oil film between the pistons and cylinder walls is maintained even under extreme operating conditions such as: when starting in cold weather, continued high-speed operation with its consequent high cylinder temperature, and in high-air temperature.

The special construction of this alloy piston allows the fitting of the piston to the cylinder barrel with approximately the same clearance as is given to a cast-iron piston at a normal room temperature

of 70 degrees. On the camshaft side of the piston, and between the ring belt and skirt, a horizontal slot is cut, while on the opposite side a T slot is formed as shown in Fig. 1. This, combined with the special shape of the piston obtained by cam grinding, allows the close fitting previously mentioned. Piston distortion under heavy load is held to a minimum because the piston pin bosses are attached to the piston head by way of heavy struts. It is important when in-

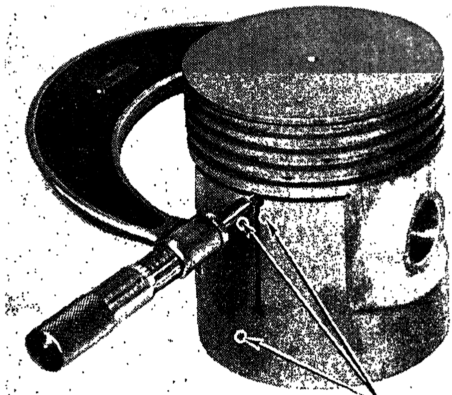


Fig. 2. Taking Measurements for Piston Clearance
Courtesy of Buick Motor Company, Flint, Michigan

stalling compression rings, of the undercut or grooved type at the lower corner, that they are always placed with undercut corner down.

From the following it will be seen that the clearance allowance is very small. Series 40 clearance is .0018 inch to .0024 inch and on the series 60, 80 and 90, .0020 inch to .0026 inch. The desired clearance being midway between these given in each case.

Accurate clearances are best found by measuring the cylinder bore with inside micrometers, and the piston with outside micrometers as shown in Fig. 2. The micrometers should be accurately checked against each other. Notice how the piston stands on the skirt when taking these measurements. As the skirt is very flexible, a very delicate touch must be used in getting the feel of the micrometer, otherwise a false measurement will be taken.

Packard Pistons. The pistons used in the Packard 120 engines are of aluminum alloy, giving strength because of the steel strut construction, with lightweight reciprocating parts. The skirt is slotted, and the piston is installed in the cylinder bore so that the slot is away from the camshaft. They are fitted with a minimum clearance of .0015 inch at the skirt.

To fit the piston to the cylinder bore, a feeler gauge, .0015 inch thick, half an inch wide, and 8 inches long, is placed between the piston and cylinder walls. The feeler is placed between the piston and cylinder walls on the opposite side to the slots in the piston skirt. The piston is considered correctly fitted if a pull of five to seven pounds on a spring scale attached to the feeler is required to pull the feeler strip out.

To attain the correct piston pin fit and to allow the correct clearance necessary for proper lubrication, the piston should be heated to 160 degrees. This can be done by immersing the piston in hot water. The piston pin is then fitted to the piston with a palm push fit. The piston pins are fitted to the connecting rod bearings with a thumb push fit, with the bushing at room temperature of 70 degrees.

Pistons and connecting rods can be removed from the engine as complete assemblies, by way of the cylinder block. A connecting rod and piston assembly should be installed with the bleed holes on the camshaft side, and the piston slot away from the camshaft. Before installation all parts should be thoroughly cleaned and well lubricated so that there is no lack of lubrication when the engine is first started.

Piston Pins. Piston pins are made from hollow stock. This is done in order to prevent undue weight. The service of the piston pin is a very severe one. While the motion is a reciprocating one, the temperature at which the parts operate is very high and lubrication is rather difficult. The oil may be so thinned by heat that most of its lubricating qualities are lost. Formerly it was not unusual to find a piston pin of small diameter worn very badly on each end where it fitted into the piston boss. This is rarely the case with the light-weight pistons and small-bore engines in use for passenger-car service in modern engines. Another fact which has helped to prevent undue wear on the pistons is the practice of hardening the piston pin. Piston pins are so hard when they leave

the factory that it is impossible to cut them with a file. This was not true in the early days. All piston pins are finished by grinding

Fig. 3. A Variety of Piston Pins, Showing Provisions for Locking
Those with the largest diameter represent modern practice. Those of small diameter represent obsolete styles.

and the first-grade pins are true within .0001 inch. Fig. 3 shows a variety of piston pin designs.

Fig. 4. Pontiac Slotted Piston Pin
Courtesy of Pontiac Motor Company, Pontiac, Michigan

Pontiac Piston Pins. A new method of fitting piston pins is found in the Pontiac engine. The piston pins are individually selected for proper fit to close limits to the connecting rod bushings. See Fig. 4.

One end of the pin is locked in place by the conventional method of a locking screw as shown in Fig. 5. The other end of the pin

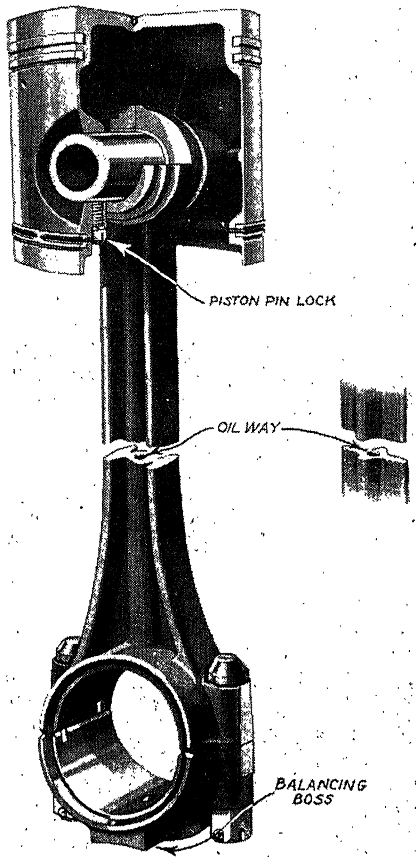


Fig. 5. Piston-Pin Lock on Pontiac Pins
Courtesy of Pontiac Motor Company

is slotted, as shown in Fig. 4, to allow for the expansion and contraction which takes place as the engine temperature changes. This arrangement insures correct fitting under all conditions, and prevents piston pin noises.

Methods of Locking Piston Pins. Perhaps there is no point about an engine at which failure is accompanied with such unfortunate results as is the failure of the piston-pin locking device. Almost invariably this permits the piston pin to work to one side or the other, and cylinder scoring results. While the piston and the piston pin may be replaced quite readily, it is entirely different

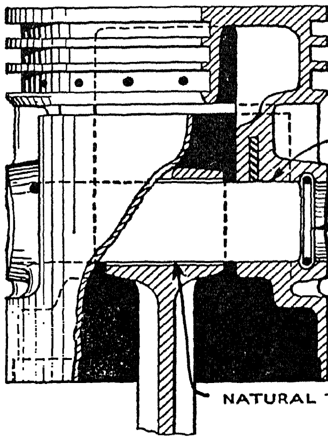


Fig. 6. Piston Pin Retained by Means of Hardened Steel Ring

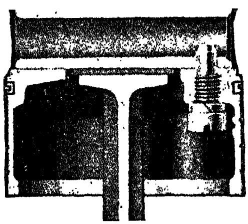


Fig. 7. Piston-Pin Locking Device

It consists of a screw running through the lower side of the piston-pin boss and through the pin. The lock washer keeps the locking screw from backing out.

when it comes to reconditioning the cylinder block. Too much care cannot be used in checking up and securing this locking device. Fig. 6 shows the use of the small steel spring ring which is inserted in a groove provided at the outer end of the piston-pin boss; two of these being used per piston. This leaves the piston free to float

within the connecting rod upper end and the piston-pin bosses, or a shrink fit in the bosses may be used.

Another method of locking the piston pin is to fasten one end of the piston pin in one of the piston-pin bosses. This is usually accomplished by means of a set screw, Fig. 7, which in turn is prevented from backing out by means of a wire, lock washer, or cotter key.

Piston Rings. Originally there were two types of rings which were considered good. However, the three rings shown in Figs. 8, 9, and 10 are the three different types of piston rings in common use today.

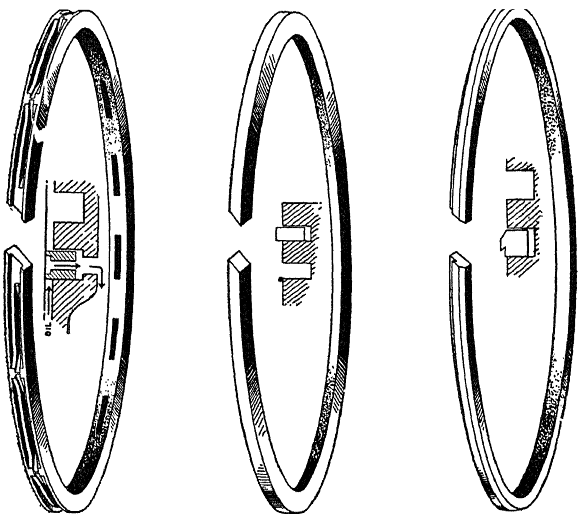


Fig. 8. Super-Drainoil Piston Ring

Fig. 9. Plain Compression Piston Ring

Fig. 10. Oil Scraper Piston Ring

Courtesy of Sealed Power Corporation

Piston Failure. Conditions under which pistons do their work make them constantly liable to failure. From the moment the new engine is started, wear is taking place. Engineers speak of the initial "running-in" period of an engine as the "wearing-in" period. They recognize the fact that it is practically impossible to fit up new parts with just the exact clearance which they desire them to have after they have been run in. For this reason they fit the engines up a bit closer than they should be and after the initial

running-in period of five hundred to one thousand miles enough wear will have occurred to give just about the clearance which the engineers desire.

From this point onward, however, the wear of the engine parts does not cease. When the piston is on its downward stroke under the power impulse, it is thrown violently to the side of the cylinder with the result that some wear is taking place. On the upward stroke it is thrown to the other side of the cylinder and on the compression stroke considerable force is exerted on that side. Under ordinary conditions wear is very slow. Under conditions of

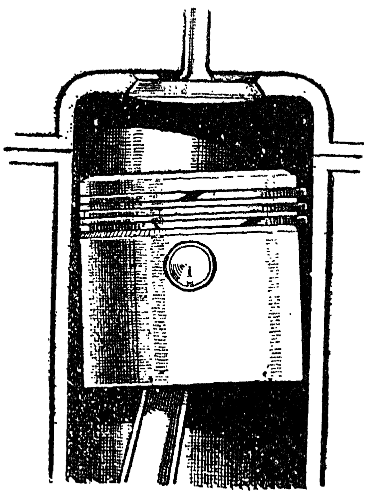


Fig. 11. An Exaggerated View of a Worn Piston
This results in what is termed "piston slap."

poor lubrication and excessive load or heat wear may be very fast. At any rate there comes a time, sooner or later, in the life of the piston where a condition such as that shown in Fig. 11 is certain to exist. This illustration shows an exaggerated view of a worn piston within a cylinder. Owing to the angularity of the connecting rod, this piston would slap from side to side in the cylinder and give off a very disagreeable noise when the engine was operating. Generally speaking, when wear exceeding the amounts provided when the engine is assembled in a new or rebuilt condition by as much as .005 to .010 inch, piston slap will be noticeable. Under those

conditions it will be necessary to recondition cylinder and fit oversize pistons, fit piston expanders or otherwise recondition pistons.

Failure of Lubrication System. Fig. 12 illustrates a pair of pistons taken from the same engine after forty-two thousand miles of service. The one piston is in perfect condition except for the normal wear. The cylinder from which it came was likewise in good condition. The piston at the left is badly scored and the cylinder it came from was also badly scored. The condition was due to the failure of the lubrication system together with an accumulation of carbon between the piston and cylinder walls. When

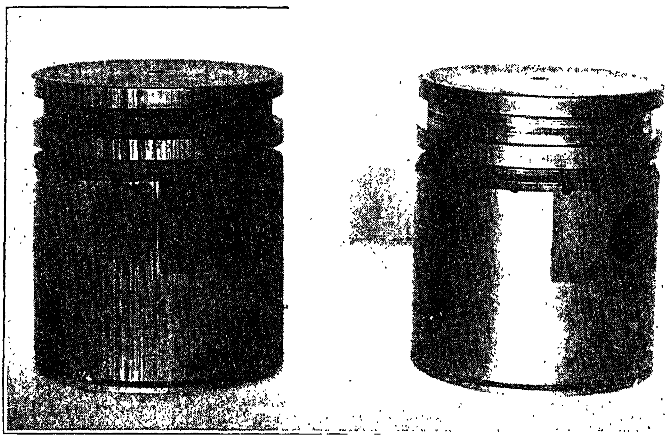


Fig. 12. Two Pistons from the Same Engine
The one is scored and the other is in normally worn condition.

failure such as this occurs, it means that the cylinder will have to be reconditioned and new pistons fitted.

Compression. The first question asked by the repair man when considering the condition of an engine is, "How is the compression?" When he asks this question he is thinking about the condition of the cylinder walls, the condition of the pistons, the condition of the valves, the condition of the head gasket, and the condition of the piston rings. All of these must be in perfect condition in order to insure the compression of the engine being even in all cylinders and up to the specifications of the engineers.

Compression refers to whether or not the charge which is drawn in on the intake stroke is held within the cylinder or whether it is

leaking out when the piston is brought up from bottom dead center. Of course there is the question of good gaskets and properly seated valves involved as well as those units which are used to seal the lower part of the cylinder.

The poppet type valve may be and very likely is the cause of compression loss more than any other part of the engine; but when valves are in condition and new gaskets are properly set up, failure is then likely to be traced to the rings and pistons.

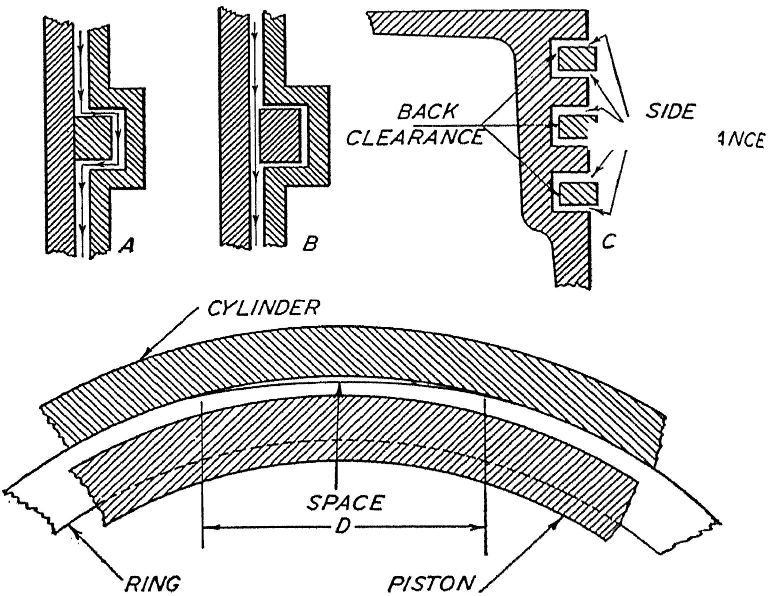


Fig. 13. *A*—Compression Losses around a Badly Worn Ring
B—Compression Losses past the Ring
C—Ring Clearances. Some Clearance Must be Allowed for Plain Rings
D—Losses of Compression Due to Cylinder Distortion or Poorly Fitted Rings

Unless the piston is a fairly snug fit to the cylinder walls, it will be impossible to fit rings so that they will retain the compression for any length of time unless some of the special types of rings are used These will be described at a later point.

The way in which compression losses occur with reference to the rings and pistons is illustrated in Fig. 13. At *A* gases are indicated leaking around a badly worn ring, between the back of the ring and the ring groove. At *B* another type of loss is illustrated.

Here the ring still fits the groove fairly well, but the tension of the ring has been lost and the compression is finding its way down past the outside of the ring and along the cylinder wall. Another loss which may occur at the ring is illustrated at *D*, which shows a "flat" on the outside of the ring. The same condition would exist if the cylinder wall were scored in such a way that the ring could not conform to it. The student will want to study the illustration at *C* to learn what is meant by back clearance and side clearance of piston rings.

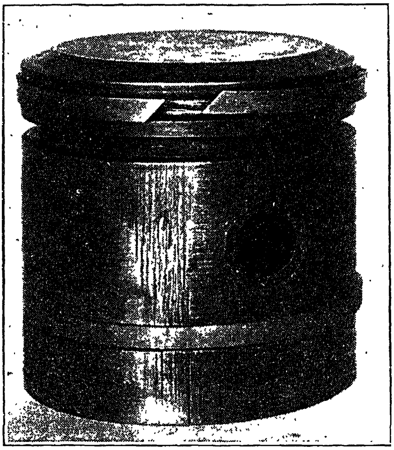


Fig. 14. Piston Scored from the Effects of Excessive Heating and Accumulation of Carbon
The ring has been warped by excessive heating.

Unless the depth of the ring groove is greater than the thick ness of the ring itself, the ring will be bound within the cylinder, lubrication will be poor, and it very likely will result in a sized ring and piston assembly.

Overheating of Pistons. Fig. 14 illustrates what may happen if a piston becomes overheated. Overheating may be due to many causes, the most usual ones being lack of oil, poor grade of oil, lack of water in the cooling system, and an overload placed on newly fitted parts.

It is possible to wear out an engine before you wear it in. All engineers appreciate this and specify that their cars should be

operated at moderate speeds until parts have had a chance to wear in. The garage man must learn to insist on the same type of treatment for the newly overhauled engine. Parts are not smooth when reconditioned. They must wear smooth while in contact with each

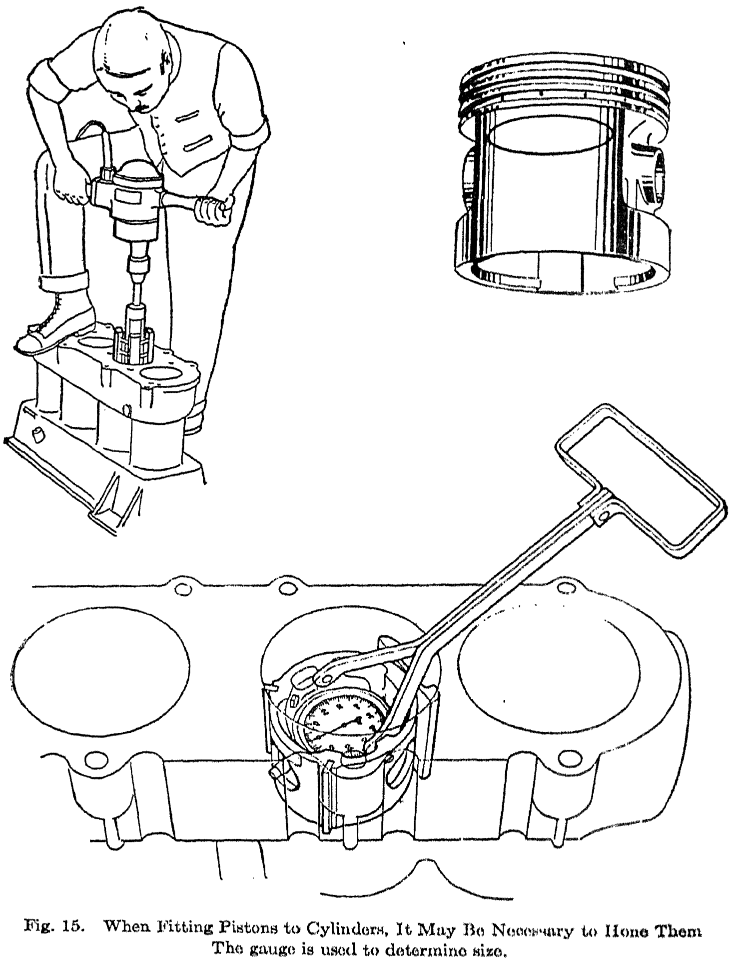


Fig. 15. When Fitting Pistons to Cylinders, It May Be Necessary to Hone Them
The gauge is used to determine size.

other. This wearing-in process generates friction, and friction generates heat. When a piston starts to heat up, it expands and as it expands it will rub all the harder on the cylinder walls. This means that more friction will occur, consequently more heat will

be developed. If the garage man understands this clearly, he is going to insist that he will not assume the responsibility for a piece of work that he has just completed if the owner will not "run in" the engine according to his directions.

Reconditioning Cylinders for New Pistons. This feature was discussed fully in a former chapter and is repeated here for the sake of emphasis on good practice when reconditioning cylinders. Too much stress cannot be laid upon the fact that it is impossible to secure good compression if the cylinders are not true. It is poor practice to try to fit new pistons to cylinder walls which are badly worn. They should be reconditioned by means of the hone or some

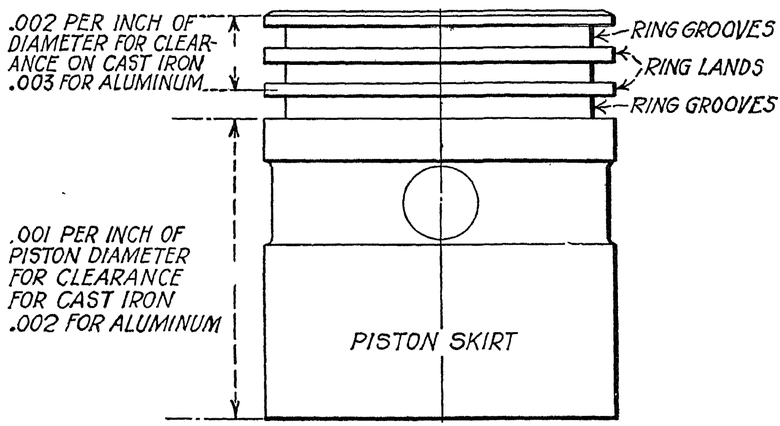


Fig. 16. Nomenclature of Piston Parts and Rule for Piston Clearance

of the other types illustrated in the former chapter. Test the cylinder bores, as shown in the lower view of Fig. 15, by means of proper equipment and then the pistons, if needed, may be fitted as described later on in this chapter.

Piston Clearance. When it has been decided to fit new pistons, the first thing is to recondition the cylinders. Then, when fitting the pistons, it will be necessary to have some rule to go by unless the exact specifications of the car manufacturer are at hand.

The different parts of the piston are the piston ring groove—the part in which the piston ring is placed; the ring land—the part between the grooves; the skirt—the part below the power piston ring

groove; see Fig. 16. The repair man should be careful to check the clearance when installing new pistons. Clearance is the difference in size between the piston diameter and the cylinder diameter. The piston should be much smaller at the ring lands than at the skirt, because there is greater heat at the top therefore greater

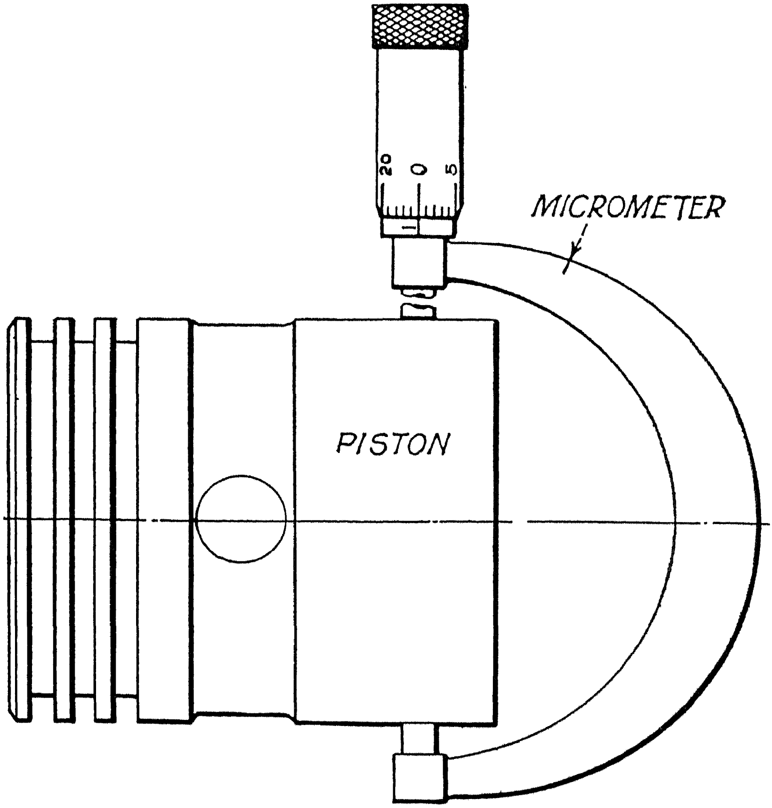


Fig. 17. Measuring Piston with Micrometer

expansion. A good rule for cast-iron piston clearance is, *two thousandths (.002) inch should be allowed at the ring lands for each inch of piston diameter, and one thousandth (.001) at the skirt.* Aluminum expands more than cast iron, therefore aluminum pistons must have more clearance. For this type of piston the rule is, *three thou-*

sandths (.003) inch at the ring lands and two thousandths (.002) at the skirt for each inch of piston diameter, Fig. 16. This rule is not hard and fast but is a safe one to follow. The piston should be measured with a micrometer to see if it is perfectly round before fitting it to the cylinder. The aluminum pistons referred to are of the solid (non-slotted skirt) type.

There are two ways of testing the clearance of a piston: one by the use of the outside and inside micrometers; the other, by the use of a thickness gauge. To use the micrometer it is necessary to find the size of the piston and then the size of the cylinder, Figs. 17 and 18. Subtracting the size of the piston from the size of cylinder

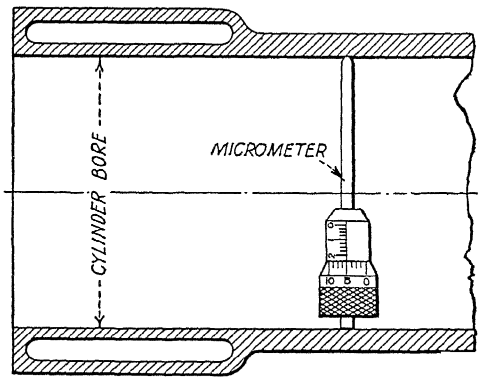


Fig. 18. Measuring Cylinder with Inside Micrometer

will give the clearance. The piston must be measured at the top and at the skirt to get the exact measurements. The feeler, or thickness gauge, is used as shown in Fig. 19. The piston is slipped into the cylinder and a leaf of the gauge is put between the piston and the cylinder walls. When the piston slides into the bore snugly with a certain thickness leaf in position, the clearance will be the thickness of the leaf. The leaf should be tried in several different positions and the piston in different positions. If the correct amount of clearance is not allowed, there is a great risk of scored cylinders; if too much is allowed, it will cause piston slap. The speed of the engine has something to do with the amount of clearance allowed. If the engine is to operate part of the time at medium speeds, the

clearance should be less than that allowed in an engine that is to run at full load at all times, as in a racing engine.

Machining Pistons. The up-to-date shop is equipped with some method of machining pistons to fit the cylinders which have been renewed by grinding, honing, or boring. Since the lathe will do a great variety of other work, it is the device usually selected for the piston machining operation.

Of course it is possible to use pistons machined to exact size by the jobber, if the jobber is in close proximity. When doing this, it is well to make a very careful reading of the bore of the cylinder

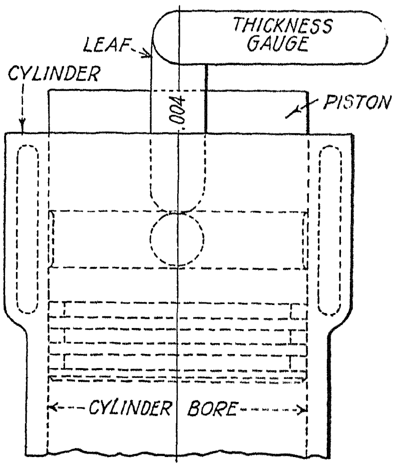


Fig. 19. Measuring Piston Clearance with Thickness Gauge

and then take a reading of the inside micrometer with the outside micrometer and send this reading along with the order. Those repair men who want to be absolutely certain of their clearance of the piston and quality of the job will also send their micrometer along with the order so that the machinist who turns down the pistons may check the exactness of the measurements provided. Not infrequently it happens that there is a slight variation in the reading of different micrometers. Any garage man may machine pistons in his own place. It is done as follows:

The first thing to do is to set up the lathe as suggested in Fig. 20 with some form of collar on which the skirt of the piston may

be rested and held in position. Most pistons are provided with a center hole in the top. After mounting up the turning collar, it should be checked to see if it is true. If it is not true, a light cut is taken from its face to bring it true. The piston is then held against this collar by means of a special screw device which has a cross member held in the piston pin bosses. Some mechanics will make up a long screw with an eye on the end of it, Fig. 21, from $\frac{1}{2}$-inch

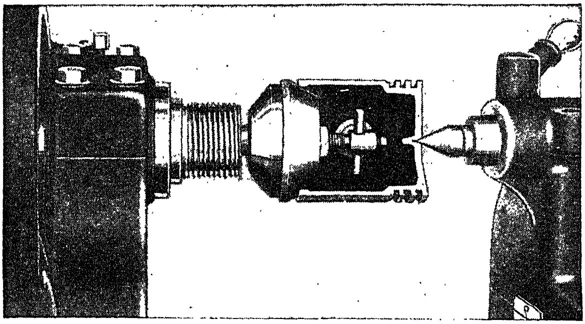


Fig. 20. Method of Set-Up for Turning Pistons in Lathe
Courtesy of South Bend Lathe Works, South Bend, Indiana

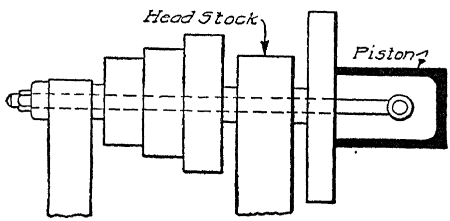


Fig. 21. Rigging for Holding Piston against Face Plate of Lathe

cold-rolled steel. This screw is long enough to run entirely through the head of the lathe with a nut and washer placed on it which draws the piston against the face plate or collar.

When pistons are to be machined in the shop of the garage repair man, he will order them from the jobber in what is known as semi-finished condition. These will run about .050 to .070 inch above standard size. The first cut then on a piston such as this is

known as a roughing cut and is illustrated in Fig. 22. Before and after the roughing cut is taken the micrometers are used to measure the diameter of the piston as indicated in Fig. 23. Finally, when the skirt of the piston has been reduced to exact size, the final operation is that of reducing the ring lands to the clearance, which

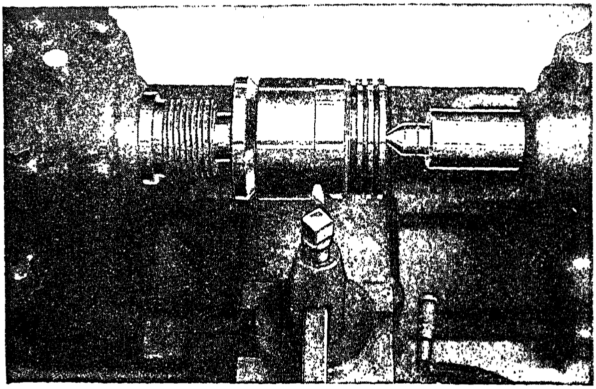


Fig. 22. Checking a Roughing Cut in Lathe
Courtesy of South Bend Lathe Works, South Bend, Indiana

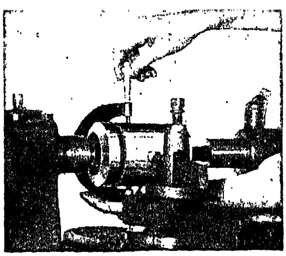


Fig. 23. Measuring Diameter of Piston When Turning
Courtesy of South Bend Lathe Works, South Bend, Indiana

may be figured as described previously and illustrated in Fig. 16. Be very certain not to neglect relieving ring lands as the piston head expands so much faster then the piston skirt, owing to the fact that it operates in a very high temperature.

Many repair men prefer to finish the pistons by grinding, since they can approximate closer fits. When this is done in the lathe,

a tool post grinder is mounted as shown in Fig. 24. The piston is reduced to approximate size by means of a turning tool, about .002 inch or .003 inch being left for the grinding operation. The piston

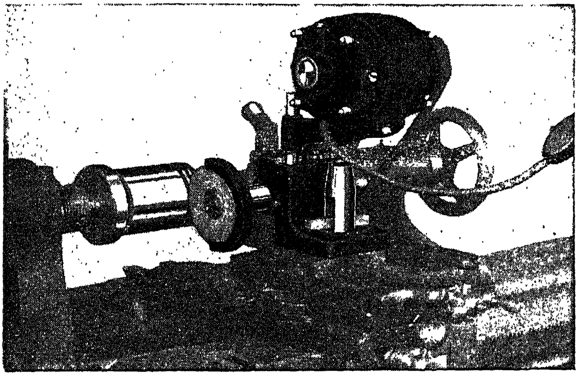


Fig. 24. Using a Tool Post Grinder for Grinding Piston in Lathe
Courtesy of South Bend Lathe Works, South Bend, Indiana

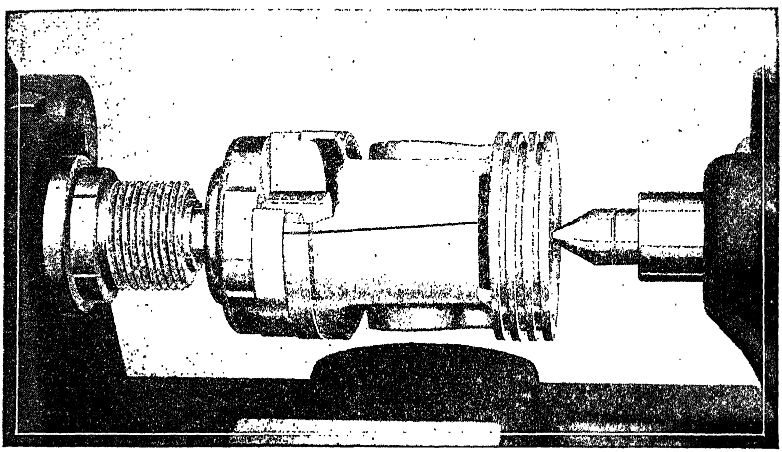


Fig. 25. A Special Mounting Collar Is Needed When Turning Split-Skirt Pistons
Courtesy of South Bend Lathe Works, South Bend, Indiana

is ground by feeding the grinder wheel forth and back across the entire length of the piston. Finally the lands are relieved by means of the grinder wheel. When doing this, each land is taken in turn.

Split-skirt pistons present a harder job when the machining operations are to be performed. This is especially true if the slot is run to the lower edge of the skirt. The best practice among the piston manufacturers and jobbers is to leave about one-half inch at the lower edge of the skirt which is not split. The piston may then be machined just as a solid type piston and the final step is to take a hacksaw and finish slotting the grooves. If the groove is wider than a single hacksaw blade, place two hacksaw blades together and the curf will be wider. Where the slot has been run all the way down, it will be necessary to use a collar similar to that used in Fig. 25. This is a special collar turned with a knife edge. When the piston is drawn down against this edge by means of a screw, the edge will bite into the bottom of the skirt and hold it.

Cam Ground, T-Slot, Aluminum Piston. Many cam ground, T-slot pistons are produced by the Sealed Power Company for standard production automobiles. This type piston is illustrated in Figs. 1 and 2. These pistons are particularly adapted to high-speed, high-compression engine performance. As noted in Fig. 1, the piston is slotted vertically, with T-slot across the top just under the bottom ring. These pistons are used without cutting the vertical slot to the bottom of the skirt. In order to prevent scoring of the piston when in use, it is necessary to have it cam ground. This cam grinding provides some flexibility and allows of the expansion of the piston toward the fore and aft wall sections of the cylinder.

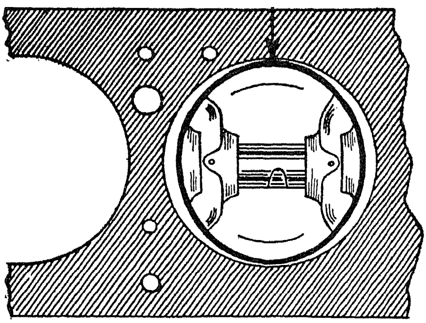
The slotted side of the piston is considered the compression thrust side, while the side opposite is considered the maximum thrust or power thrust side. The power or maximum thrust side of the piston is left considerably wider than the T-slot side in order to prevent any floating of the piston fore and aft within the cylinder. The clearance across the thrust space can be held to .001 to .002 inches for the average size piston.

In order to produce the elliptical contour of the piston, a special grinder on which the head and tail stocks are arranged to move into and away from the grinding wheel by means of a special cam action is required. Owing to the fact that not all engines are identical in operation and operating characteristics, it is impossible to specify any one particular contour for cam ground pistons. They must be ground according to the specifications for the particular

engine in which they are to be used and to this end the manufacturers of grinding equipment provide special cams of various shapes, designed to take care of the aforementioned requirements.

The method of fitting cam ground pistons to a cylinder bore is illustrated in Fig. 26. When pistons are to be fitted to the cylinder bores, they should be at the same temperature (presumably room temperature of approximately 70 degrees) as the temperature of the cylinder block. It is claimed that a variation of 10 degrees is sufficient to produce a variation of .0005 inches in piston size.

MEASURE FEELER FIT HERE



T SLOT SHOULD BE ON OPPOSITE SIDE OF PISTON FROM FEELER

Fig. 26. Fitting Buick Pistons with Feeler Gauge

After the pistons and cylinders have been allowed to come to room temperature of approximately 70 degrees, proceed to wipe the cylinder wall and the pistons with a clean cloth. Next, suspend the feeler gauge down the cylinder bore along the wall as indicated by the arrow in Fig. 26. Hold the upper end of the feeler strip with the right hand. Make certain that the gauge extends for the entire length of the bore. The thickness of the gauge to be used in the case of the Buick engine is .0015 inches. With the feeler strip in position, next hold the piston by means of the piston pin with the first two fingers and thumb of the left hand. Insert the inverted piston down the bore with the longitudinal slot opposite the feeler gauge and the wrist pin parallel to the center line of the crankshaft, or, in what would be termed normal operation position except for the inversion of the piston. If pistons are being fitted by selective fit, one should be secured which would just move down-

ward under its own weight and fitted against the feeler strip as suggested above. This fit should be checked by using a .0025-inch feeler which should be just close enough to prevent the piston moving forward of its weight alone.

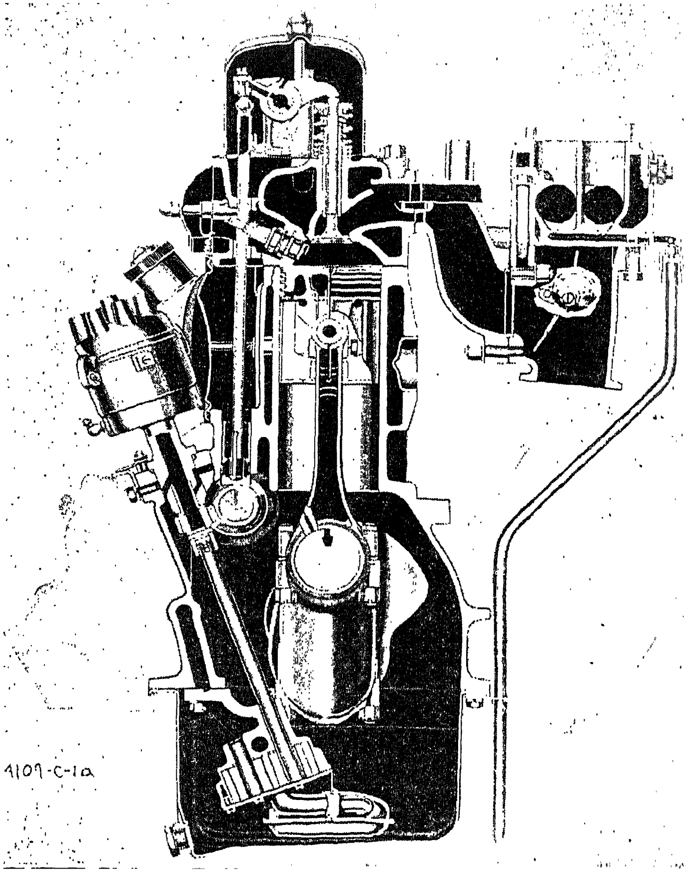


Fig. 27. Buick (1937) Engine with Clamp Type Connecting Rod
Courtesy of Buick Motor Company

The Buick 1937 engine with clamp type connecting rod is shown in Fig. 27.

Removing Piston Pins. The first step is to inspect the piston to learn what type of locking device is used. If a clamp type rod is used, make certain to remove the clamping screw from the rod

completely, otherwise damage is likely to occur owing to the fact that a small groove is provided to receive one edge of the clamping screw. It not infrequently happens that, owing to the collection of carbon and the uneven wear of the pins, the piston pin is rather difficult to remove. One method is holding the connecting rod in the vise and, by means of a hammer and soft metal drift, driving the pin through. Piston pin pullers, Fig. 28, are sometimes used, and the piston pin is forced out by turning the screw and forcing the pin ahead of it.

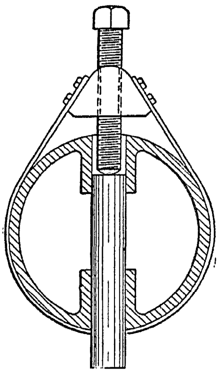


Fig. 28. Simple Piston-Pin Pulling Outfit

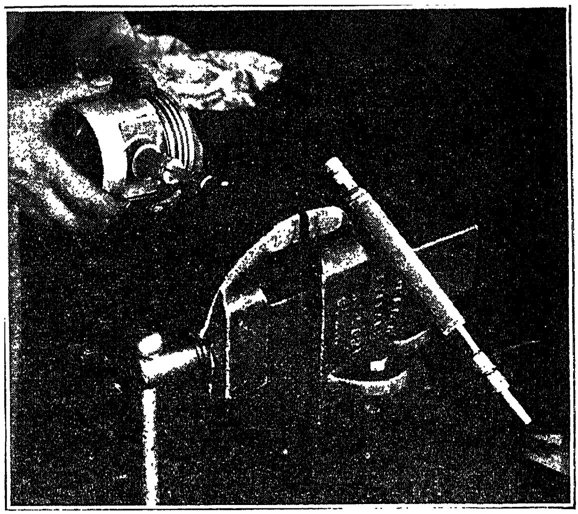


Fig. 29. Honing Piston for New Piston Pin

Fitting Piston Pins by Honing. Fig. 29 illustrates a workman honing a piston for a new piston pin. The hone is a specially designed device carrying two abrasive covered units resembling emery paper. These are held in metal members, the latter held by the hone center and arranged to be expanded by means of a micrometer adjustment. They may be used as shown, or if more metal is to be removed, they may be held in the drill press or bit brace chuck, either of these two methods speeding up the work. Hones are available in several grit numbers, fine and coarse. Hone sizes vary much after the fashion of reamer sizes, although three sizes ordinarily cover the full range of piston pin work. The same device is used for honing spring, front axle and other bushings on the car.

Reaming Piston Bosses or Piston Bushings. One of the most delicate operations to be performed in engine repair or rebuilding is the fitting of piston pins. As a rule, after the original set of pins has worn to a point where the set has become noisy, it will be necessary to ream the piston pin bosses for bushings to an oversize. The oversizes run .002″, .003″, .005″, .010″, and .020″ oversize.

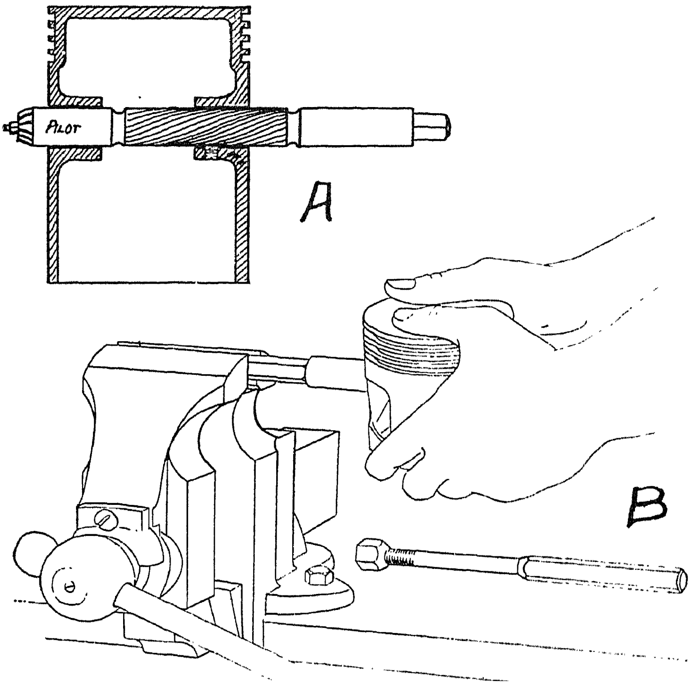


Fig. 30. Reaming and Burnishing Piston-Pin Holes

A—Using a reversed spiral reamer with a pilot. The reamer may be secured with long pilot or short. A reamer of this type (reversed spiral) will not hog into the work. It is made expanding and non-expanding.

B—Burnishing the newly reamed holes gives a better bearing for the piston pin. Reamers or burnishers may be held in the vise and the piston turned onto them by hand.

A special type of reamer has been developed for piston-pin work. There are many styles of reamers, but the important feature is to have a reamer with a pilot on it which is long enough to engage the second piston boss before very much work has been done on the first boss. If this practice is not adhered to, it will be

found that the holes in the two bosses will not align with the result that a false bearing is secured and after a short period of operation the job will have to be done over. A cross section of a piston with a reamer of this general type in use is shown at *A* in Fig. 30.

When reaming pistons, the ordinary practice is to grip the squared end of the reamer in the vise and then, holding the piston in the hands, start it over the reamer. Some manufacturers discourage this practice, claiming that not as accurate work can be done as when the piston is held in the piston vise and the reamer is turned by means of a handle, such as is used for general tapping work. Piston pins are finished to very accurate dimensions and there will be as little variation as .0005 inch in a set of six or eight.

Reamers are very delicate instruments and should be handled with the greatest of care. Do not lay the reamer on a wrench or allow the blades to come in contact with any hard metal. Preferably they should be kept in a pasteboard or softwood box, which in turn is kept free of any metal particles. The blade should be wiped clean and oiled after using.

Fitting Piston Pins with Push Fit. There are many manufacturers who recommend that piston pins be fitted with a push fit. This is the case in cast-iron or aluminum pistons where the piston pin is given a bearing in the piston bosses. It is also the case where the piston pin has its bearing in the upper end of the connecting rod.

The old practice of fitting the piston pins so tight that they had to be driven into the bushing or into the piston is not so generally used as formerly. At *A* in Fig. 31 is shown what is meant by a push fit. The piston is gripped in one hand and the pin is pushed by the ball of the other hand. If the job has been done properly, it will be just possible to push the pin through the newly reamed piston-pin bosses. At *B* in Fig. 31 is shown the same fit when used in the upper end of the connecting rod. By twisting the pin between the thumb and forefinger, as it is pushed in, the feel of the fit is determined.

In order to determine whether or not a piston pin has been properly fitted, the usual method is to make the test as shown at *C* in Fig. 31. This test is used almost universally and recommended by scores of companies. If the fit is properly made, the weight of the connecting rod will be just sufficient to descend gradually

when held as indicated. If the rod drops freely, the newly fitted job is too loose. If it will not drop at all, even when given a start, the job is too tight.

Fitting Piston Pins with Drive Fit. When the bearing is in the upper end of the connecting rod, some manufacturers recommend that the piston pin be fitted to the piston-pin bosses with a drive fit. This does not mean that a great deal of force must be

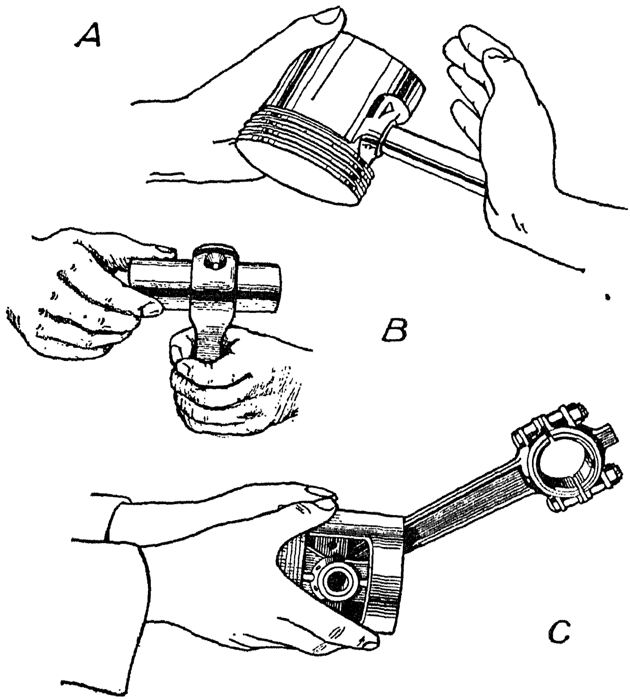


Fig. 31. *A*—Pushing Piston Pin into Newly Reamed Piston
B—Testing Push Fit in Upper End of Connecting Rod
C—Testing Fit of Piston Pin against Weight of Connecting Rod

used. It does mean that the fit is somewhat tighter than a push fit. After reaming the piston, the piston pin is started into the piston. The piston is then held on the bench top with the left hand and a rawhide mallet is used to drive the pin home. Of course the connecting rod will have been fitted previously to be in position when driving the piston pin in, so as to obviate the necessity of removing the pin and replacing a second time. Do not use a steel

hammer to strike the end of the piston pin as it will be chipped and damaged. If the piston pin has to be drifted out for further reaming, use a brass or bronze drift. When the job is properly fitted, a reasonable blow with the rawhide mallet will drive the pin home. The recommendation of the car manufacturers is that a clearance of .0 inch to .0005 inch is the proper amount to give a drive fit for a piston pin in cast-iron pistons. Note *A*, Fig. 32.

Fitting Piston Pins with Shrink Fit. Aluminum pistons were not on the market very long until mechanics learned that a very easy way of installing or removing piston pins was to dip the piston

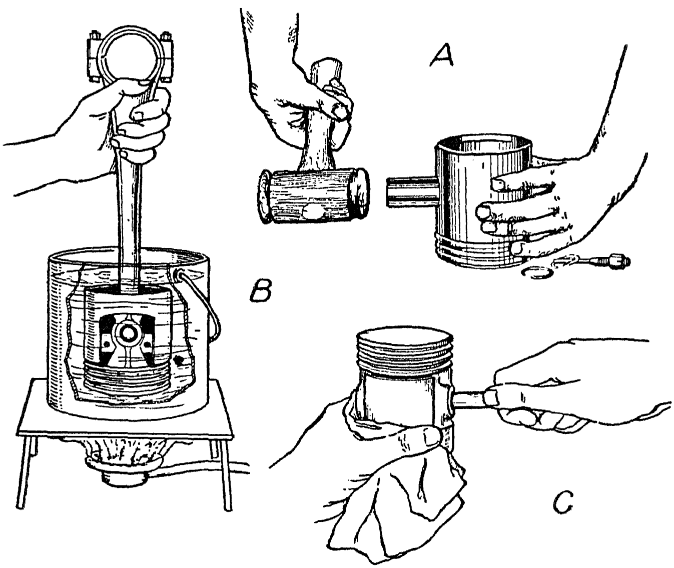


Fig. 32. *A*—Drive Fit for Piston Pin in Cast-Iron Piston
B—Heat Piston in Water for Removing or Installing Piston Pin
C—Pushing Piston Pin Home in Heated Piston

into a kettle of boiling water, which would cause the aluminum to expand sufficiently to allow the pin to be slipped out of or into position. Motor manufacturers are recommending this practice for certain types of work. With the skeleton piston and the invar strut piston, the practice is to ream the piston-pin bosses until the new pin can just barely be started. Make certain that the piston-pin holes are the same diameter for their entire length. The piston is then dipped into boiling water by holding it as suggested at *B*

in Fig. 32. By holding the piston in the hand, the pin may be pushed out or in very readily as suggested at *C* in Fig. 32.

Rounding-Up Out-of-Round Pistons. Pistons, when machined, are supposed to be round. Owing to the fact that metal warps in cooling, just as wood does, the pistons may not remain perfectly cylindrical. Then again they may be damaged slightly when shipping or when handling. Pistons should be carefully checked with the micrometers before installing in the cylinder. If it is found that they are not perfectly round, being out of round a slight amount, say .002 to .005 inch, they may be rounded up as suggested in Fig. 33. The piston is inverted on the bench top, held with the left hand and struck with a rawhide mallet on the high spot. A

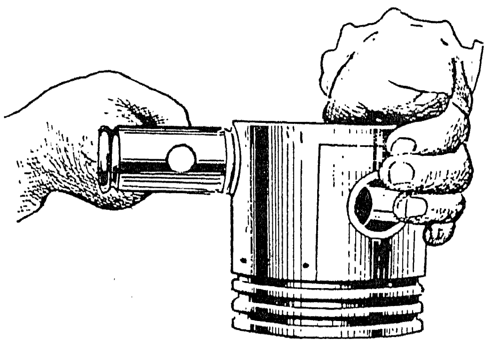


Fig. 33. Using a Rawhide Mallet to Round Up an Out-of-Round Piston

little hammering will quickly round it up. Under no circumstances should a steel hammer be used for this work, but a rawhide or a lead hammer is recommended. The blows should not be too heavy. Some mechanics prefer to round up the piston by squeezing between the jaws of the vise. In this case, the copper jaws should be in place or the jaws should be protected by means of wood strips.

Piston-Ring Travel and Ring Wear. The point not always realized by the new repair man is the fact that piston rings will wear the cylinder to a greater extent than the piston itself wears the cylinder, resulting in a condition such as illustrated in Fig. 34. In many cases there are no rings below the piston-pin boss and the ring travel is just about half of the length of the cylinder. It is not unusual to find the ring wear exceeding the wear at other points

in the cylinder by as much as .020 inch. It is quite possible in many cases to fit new rings without reconditioning the cylinder and get good results; but if the cylinders are worn considerably, it is obviously almost impossible to secure satisfactory results, owing to the fact that the piston itself will have so much clearance that the new rings will not seat properly when the piston slaps from side to side. There are certain types of rings on the market which are recommended for such a condition.

Removing Piston Ring Wear Ridge. The Hall ring ridge reamer, Fig. 34-A, is designed to remove the ridge left from normal cylinder

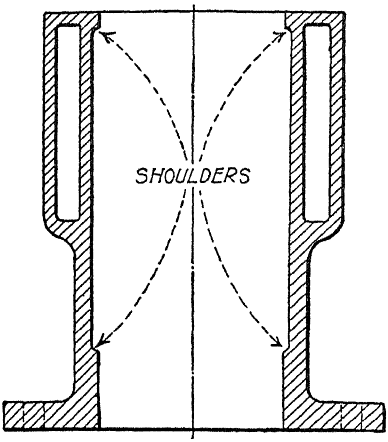


Fig. 34. Cross Section of Cylinder, Showing Evidence of Wear Caused by Piston Ring

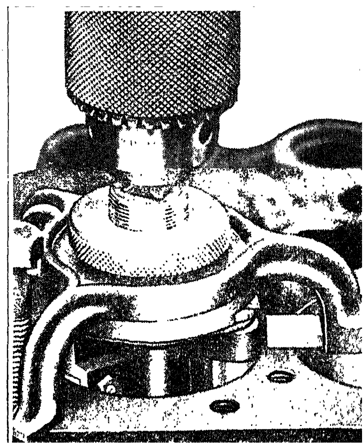


Fig. 34-A. Removing Piston Ring Travel Ridge
Courtesy of The Hall Manufacturing Company

wear. It is clamped to the top of cylinder block, the depth of the cut is gauged and the shoulder or ridge is cut away. If this operation is not performed, the new rings which are installed will contact the bottom of the ridge and a pinging or knocking noise will be the result.

Removing Piston Rings. Piston rings are made from a fine grade of cast iron. Cast iron is rigid and if an attempt is made to spring it to any great extent, it will snap. When made up in the form of a piston ring, it has a certain amount of tension or spring and may be handled successfully if the workman keeps in mind its limits. The beginner very frequently breaks the cast-iron

piston rings because he does not understand the nature of the metal. The point at which most ring breakage occurs is either in removing or installing the rings on the piston. Fig. 35 shows a ring expander and methods of using skids to install or remove the piston rings. This method has been in use for many years and while it is slow it is also satisfactory. When installing piston rings by means of these skids, the first step is to hook the ring on to the piston as shown at *E*, Fig. 36; and when it is snapped over the piston, slip the skids back of it and force the ring downward into

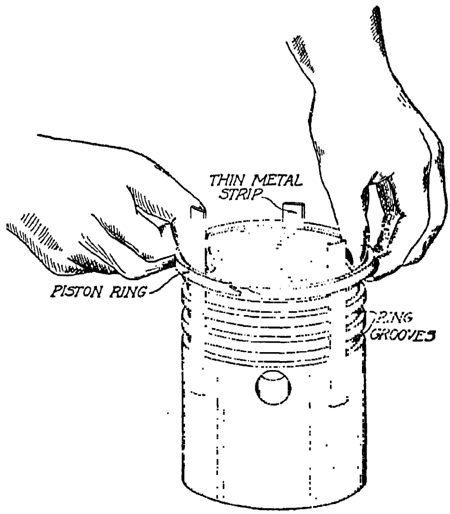


Fig. 35. Using Piston Ring Skids for Installing or Removing Pistons

the groove for which it has been fitted. A somewhat similar method of removing rings is illustrated at *C* and *D*, Fig. 36, which is the practice recommended by the Chevrolet Company. A hardwood handled thin steel blade case knife is a good tool for this work. Slip the blade of the knife back of the ring and run it round the piston, forcing the ring out of the groove, at the same time holding one end between the thumb and forefinger of the other hand and gently lifting upward. Do not use any great force to pull upward or the ring will be sprung and possibly broken.

Skids recommended by the Continental Motors Company are illustrated at *B*, Fig. 36. These consist of two strips riveted at the center and make a handy set of piston-ring skids.

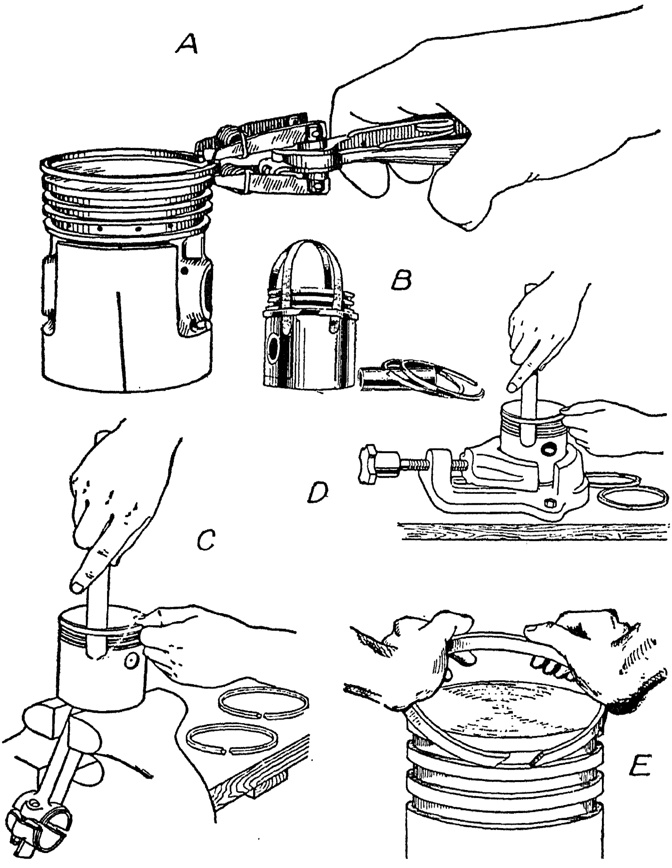


Fig. 36. *A*—Using Special Piston-Ring Remover
B—Skids Recommended by Continental Motors
C—Removing Rings from Piston and Rod Assembly
D—Removing Rings from Piston While Holding It in Piston Vise
E—Starting to Replace Piston Ring

Owing to the demands made upon mechanics when they are working on the flat-rate basis, manufacturers have designed tools which will permit them to speed up their work so as to enable them to earn a satisfactory wage. One of these tools is the piston-ring removing tool, shown at *A*, Fig. 36. This tool grips the ends of the

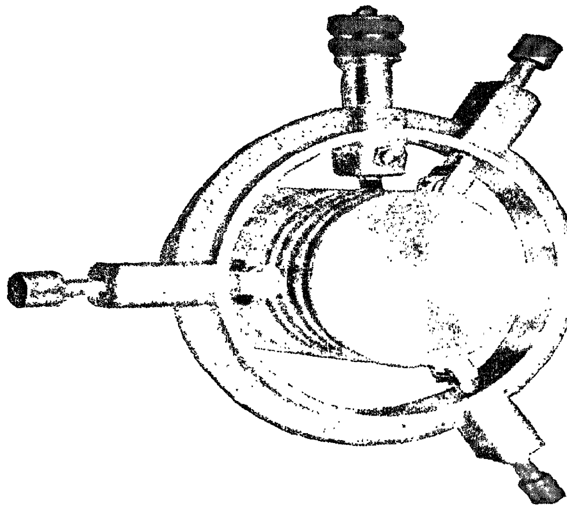


Fig. 37. Tool for Squaring-Up Piston-Ring Grooves

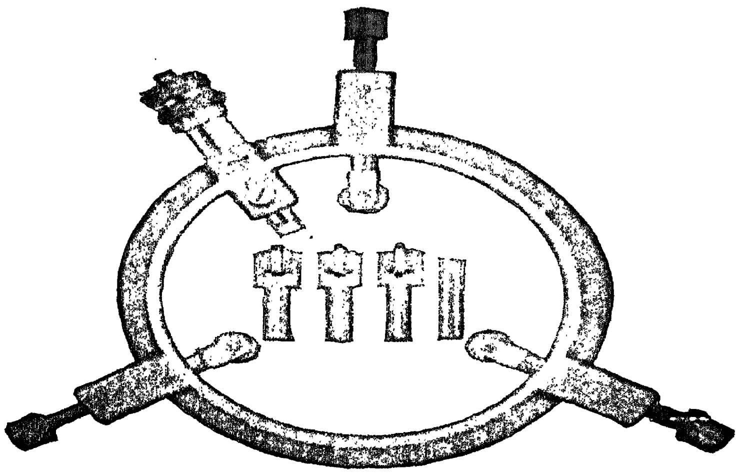


Fig. 38. Piston Re-Grooving Tool with Fittings

ring and at the same time expands the ring. The two handles are gripped and pulled together by the hand of the operator, thus enabling the workman to do with one hand what ordinarily requires two and leaving the other hand free to guide the ring off of the piston. There are a number of similar devices on the market.

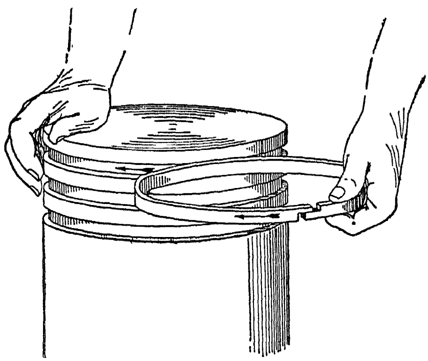


Fig. 39. Testing Fit of Piston Ring in Ring Groove by Rolling

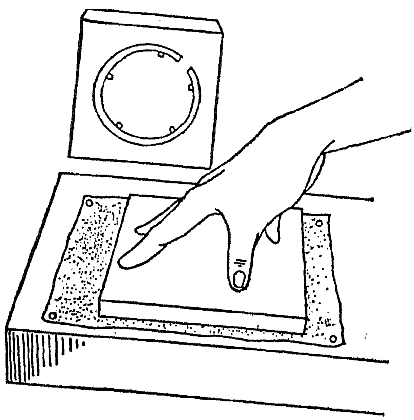


Fig. 40. Method of Holding Piston Ring to Grind It Down on Emery Cloth

Fitting Piston Rings in Piston-Ring Groove. While piston rings are machined to very fine standards, it is generally found to be true that they will not fit the grooves of an old piston perfectly. They are made just a bit oversize to allow for some dressing down to bring them to size. Fig. 37 shows the tool used for squaring-up

piston-ring grooves and Fig. 38 shows the tool for regrooving. The method universally recommended for testing the fit of the piston ring to the piston groove, is shown in Fig 39. The ring is rolled around the groove to see whether there are any points at which it will not fit. If it does not fit, it should be dressed down on a sheet of emery cloth. The emery cloth is tacked to a board as shown in Fig. 40. Another small board has some nails in it. These nails are used to support the ring or hold it when doing the grinding operation. They should be in a circle just large enough to hold the ring securely. When grinding, the motion is a rotary one, care being used to grind the ring evenly, after which it is again tried for a fit, as suggested in Fig. 39.

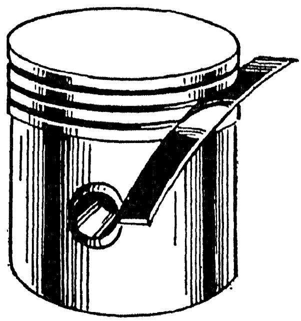


Fig. 41. Using Thickness Gauge to Test Ring Fit

The amount of clearance between the ring and the groove (up and down clearance) should be not more than .001 inch. This is tested as illustrated in Fig. 41. If the .0005-inch blade of the thickness gauge can just be forced in over the ring, as shown, the workman may feel certain that the fit is not too tight as it is likely that there will be about .0005-inch clearance more than the thickness of the blade. When the ring is installed, there should be no point at which it will not move out or in the groove freely.

Tapered Ring Groove. Experienced mechanics know that ring grooves will wear tapered, as illustrated in Fig. 42; that is, the ring groove is wider at the outer edge than at the back. This is due to the fact that the piston ring has been expanded against the side of the cylinder wall and has worn the outer edge of the ring lands more than

the back portion. It is difficult to fit rings to a piston which is in such condition. Rather than attempt to do this, it is recommended that a tool such as that shown in Fig. 37 be employed to clean out the ring grooves and to turn them parallel as shown in Fig. 42. This means that an oversize ring will need to be purchased. A similar piece of work may be done if the cylinder is mounted in the lathe. A square-nose tool should be provided, which would have exactly the same width as the ring to be installed. For instance, a $\frac{3}{16}$-inch ring might be installed in place of a $\frac{1}{8}$-inch ring or a $\frac{1}{4}$-inch ring might be installed in place of a $\frac{3}{16}$-inch ring.

Fitting Piston Rings to Cylinder Wall. After the piston ring has been fitted to the ring groove, it should next be fitted to the

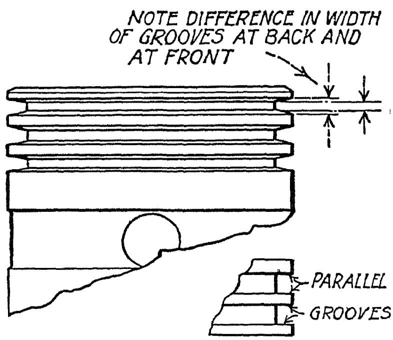


Fig. 42. Ring Grooves Will Wear Tapered

cylinder wall with the proper end clearance. The end clearance recommended varies for the different rings, more being provided for the top ring than for the bottom one. This is due to the fact that the top ring receives most of the heat and the lower rings not becoming so hot do not expand so much. In order to check the clearance of the ring, it should be placed in the cylinder in position and a light should be dropped into the cylinder and the clearance should be measured as indicated in Fig. 43. The amount of clearance on a bevel-cut ring is one and one-half times that of the thickness of the blade of the thickness gauge, which will just fit it. This is owing to the fact that the bevel is on approximately a 45-degree angle. When measuring step-cut rings, the clearance is exactly as indicated by the thickness of the blade used in checking. Fig. 43 il-

lustrates the use of an old piston in the cylinder on which the ring being fitted may be dropped to be sure that it is perfectly true. Roughly speaking, the clearance of the top ring should be not less than .003 inch for each inch of diameter of the cylinder. The next ring should be .002 inch for each inch of diameter, and the third ring should be not less than .0015 inch. Experiments show that comparatively slight amounts of compression loss in the cylinder are

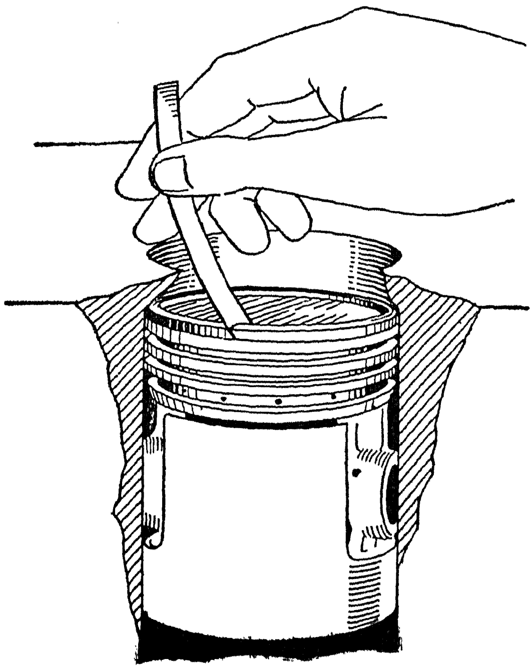


Fig. 43. Testing End Clearance of Piston Ring in Cylinder

due to the loss past the ring ends. This is somewhat contrary to the generally accepted belief. As a matter of fact, more compression is lost past the outer edge of the ring and round the back of the ring many times over than is lost between the joints of the ring, even though these be somewhat wide. A very serious trouble may result if newly fitted piston rings do not have room to expand when the running-in process starts. Scoring may result to rings, pistons,

and cylinders, if the ring expands until the ends lock tight together and no further expansion is possible. When filing ends of rings to reduce them to proper size they may be held between the copper jaws of the vise, as indicated in Fig. 44, and the file, which should be a fine-cut mill file, run between the ends. Some mechanics prefer to hold the file in the vise and hold the ring in the hands. The method is immaterial as long as care is used not to spring the ring and to secure the proper fit. The ends should touch perfectly when the ring is compressed to bring them in touch with

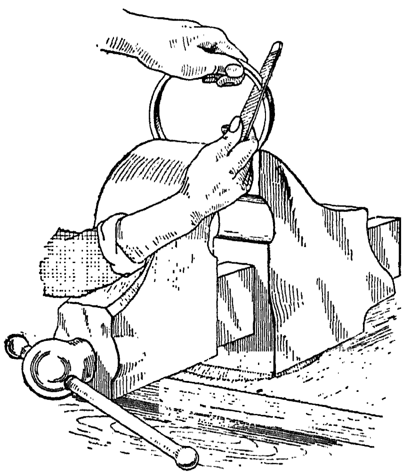


Fig. 44. Filing Ends of Piston Ring When Fitting to Cylinder

each other; that is, there should be no high points, but the entire ends of the rings or the steps should meet.

Balancing Pistons. Motor car manufacturers have long since recognized the need of exact balance of reciprocating parts because it reduces vibration. This means the rod and piston assemblies must have exactly the same weight. It is not only essential that the assemblies have the same weight, it is also essential that the independent parts of the assembly weigh exactly the same. For this reason pistons installed should be carefully checked, Fig. 45, so that there will not be more than the slightest fraction of an ounce variation in the weights. If it is found that a new piston

is overweight, it may be reduced by drilling holes in it. Select a point for drilling the holes about midway between the bottom of the piston and the piston pin hole, thus the hole will not appear on the portion of the piston which gets the thrust nor will it weaken the piston by being too close to the piston pin boss. These will not interfere with the efficiency of the piston in any way.

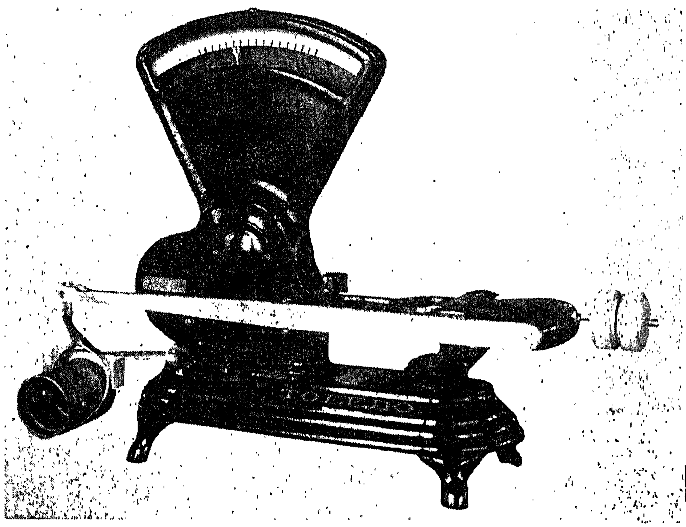


Fig. 45. Pistons Must Be Weighed or Balanced Accurately to Prevent Vibration and Allow Engine to Develop Most Power
Courtesy of Toledo Scale Company

Pontiac Connecting Rod Balancing. The connecting rods in the Pontiac engine are very carefully balanced in respect to both total weight and center of gravity. Laboratory tests are made to determine the correct center of gravity of the rod and what each rod should weigh. After machining the rod, it is placed on a special balance, so that the small end falls exactly in line with the knife edge of the scale, while the rod rests on a bracket attached to the scale pan. A reading on the scale determines the amount of metal which must be removed from the boss on the big end cap, that is used for balancing purposes, in order to reduce the weight of the other end to the required standard weight. After machining, a

further check is made and, if not correct, further machining and checking are done until the scale balances as required. After the big end of the rod is brought to the predetermined weight, the small end is brought to the standard weight for that end. This insures the rod being in perfect balance for weight and center of gravity. Such balancing reduces vibration and gives a smooth running engine.

Oil Pumping. One of the greatest troubles experienced in the automobile engine is oil pumping. The indication of oil pumping is the continual fouling of the spark plugs, a great amount of blue smoke coming from the exhaust, and the quick formation of car-

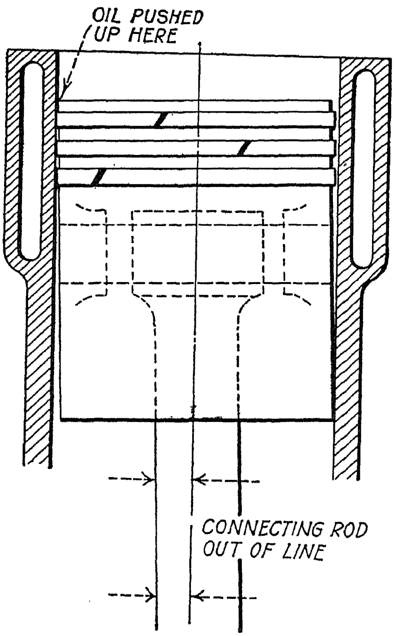


Fig. 46. Connecting Rod Out-of-Line

bon, especially if wet and sticky. Some of the causes of this trouble are relative to piston condition.

1. *A cocked piston in the cylinder, Fig. 46, which pushes the oil up into the combustion by the edge of the piston.* The cure is to check the alignment of the connecting rod and straighten it so that the piston will have equal space all around it.

2. *Rings that do not fit the piston ring grooves or cylinder walls.* Check the cylinder condition and fit new rings if necessary.

3. *Loose pistons.* Fit new pistons throughout if cylinder conditions are right. If not, then the cylinder block must be reground.

4. *Leaky valves.* Regrind.

5. *Loose main bearing in force-feed lubrication.* This allows the oil to seep out at the ends of the bearings and down the webs of

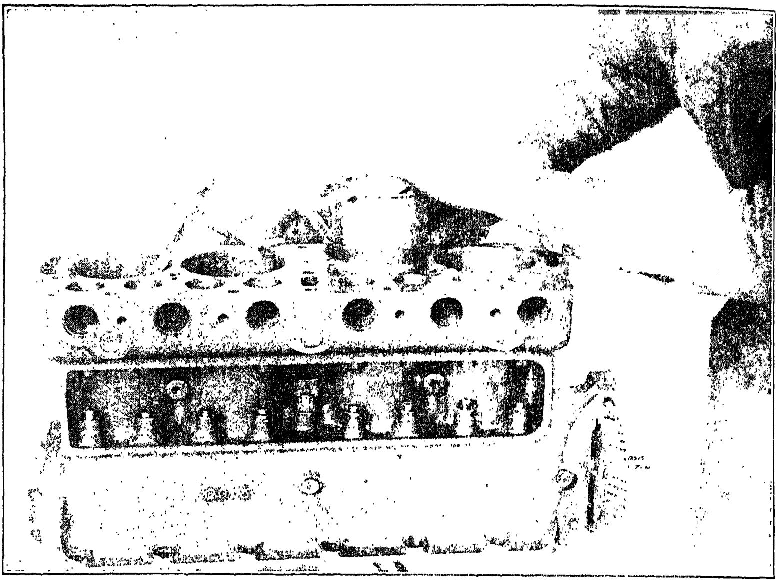


Fig. 47. Piston-Ring Squeezers May Be of Simple Design as the One Shown in Use, or the Universal Design Similar to the Tool on the Cylinder Block.

the shaft to be thrown up into the cylinders, consequently supplying more oil than the rings can handle and flooding the engine. The play in the bearings must be taken up.

Placing Piston and Rod Assemblies in Cylinders. Fig. 47 shows the use of a ring compressor used in installing pistons in 1937 Oldsmobile engines. When the pistons are installed from the top, it is comparatively simple to use one of these compressors, forcing the rings into the grooves by means of it and forcing the rings down into the cylinder with the other hand. When the piston must be forced up from the bottom, the job is not so simple. However, in

most cases where pistons are installed from the bottom of the cylinder, the builder will provide the lower end of the cylinder with a very decided chamfer. This is for the purpose of allowing the rings to be forced back into the ring groove as the piston is forced upward. Where special rings are used, that is, rings which are made in several parts, it is very desirable to have a compression sleeve. If no compression sleeve is at hand, make one out of a piece of 16-gauge sheet metal to fit the piston and use one or two stove bolts to draw the compression sleeve together.

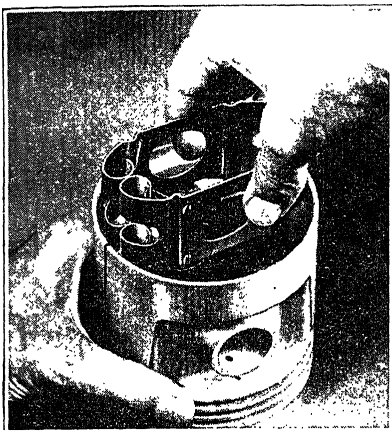


Fig. 48. Perfect Circle Piston Expander
Courtesy of the Perfect Circle Co., Hagerstown, Ind.

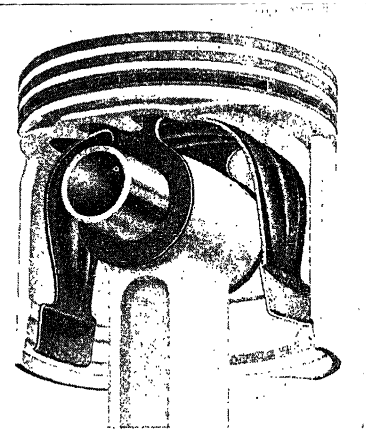


Fig. 49. Ramco Piston Expander
Courtesy of Ramsey Accessories Mfg. Corp., St. Louis, Mo.

Fitting Piston Expanders. Pistons and cylinder walls wear in service to the extent that some repair or service operation is a necessity. Normal wear sets up piston slap and oil pumping largely, due to the fact that the piston when worn has a rocking motion.

In order to overcome this trouble without putting the customer to the expense of a new set of pistons, piston expanders have been developed by reputable manufacturers. Naturally these must be selected in accord with the recommendations of the manufacturers of the several types. The piston expanders must be installed according to directions. They serve to expand the piston into contact with the cylinder wall and eliminate the troubles mentioned. Figs. 48 and 49 illustrate several makes of expanders.

Tin-Plated Pistons. The primary purpose of plating pistons is to assure a short and safe running-in period for a new engine. Incidentally, of course, the running-in period is the determining factor in the ultimate length of life of any engine. A graphic illustration of just how the tin serves to facilitate the running-in of a new engine is given in Fig. 50. An enlarged view of the section of piston and cylinder shown in the small circle at *A* is produced at the right.

The 1935 Chevrolet piston has been provided with a coating of tin one-thousandth inch thick, it being applied to the piston by a

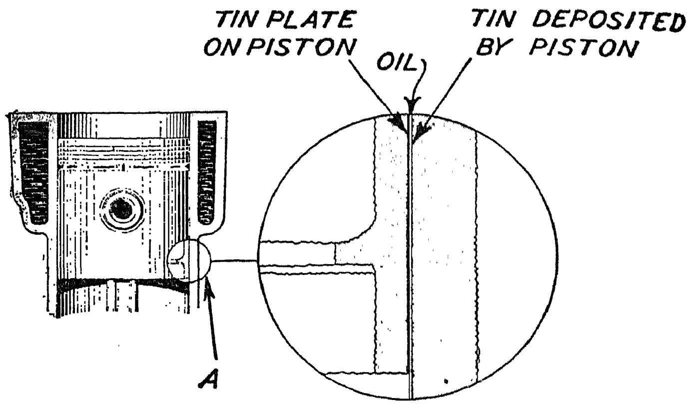


Fig. 50. Tin-Plated Piston

plating process. Anyone who is familiar with solder is familiar with the nature of tin, since most solders are about 50 per cent block tin and 50 per cent lead. Tin is softer than lead and, when the engine is started, the tin plate on the piston is in close contact with the cylinder wall and some of the plate from the piston is used to fill in the slight irregularities in the cylinder wall. Oil naturally serves to lubricate and cushion the contact of the piston on the cylinder wall. The slight amount of tin used is designed to be sufficient to fill any slight irregularity in either of the two surfaces and eventually result in a smooth surface for both the piston and cylinder bore.

Anodic Coated Aluminum Pistons. Chrysler "Airflow" and "Airstream" 1935 cars have pistons of such hardness that they virtually are immune to wear. This is achieved by an anodic coating process. By this process the piston is given a surface coating that is

as hard as a diamond and that will not "scuff." The hardening process is simple but its results are almost miraculous. The pistons are immersed for seventeen minutes in a tank containing a solution made up largely of sulphuric acid. This solution is maintained at a temperature of 70 degrees. While in the solution, the piston, carried on a conveyor, is the anode for the coating operation. It emerges from the tank with an aluminum oxide surface approximately .00025 inch thick (one-fourth of a thousandth of an inch). Aluminum oxide is one of the hardest substances known to metallurgy.

The piston, which goes into the solution with a bright aluminum finish, comes out a gun metal gray. The uniformity of color is such

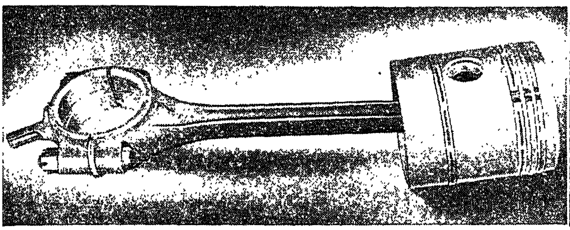


Fig. 51. Hudson and Terraplane (1935) Piston, Ring and Rod Set-Up

that probably not more than five pistons in 5,000 have to be rejected by the inspection department. The smoothness of the surface is absolutely uniform, as is the hardness. In the anodic coating process, the piston rings and piston pin hole are treated as well as the piston itself. Once the unit has received its coating of aluminum oxide, further work cannot be performed as the surface is too hard for any tool. As the coating is done in a room temperature solution, there is no distortion of the piston.

On final tests made in comparison with the regular aluminum piston, it was found a new motor in a room chilled to 10 degrees below zero would "scuff" the pistons in from 2 to 5 starts, whereas, a similar motor with the coated pistons showed no "scuffing" under exactly the same conditions after 66 starts, and the tests were discontinued as it indicated there was no comparison between the methods.

Four-Ring Piston. The Hudson piston, Fig. 51, is designed to secure better oil seal in the piston, prevent carbonizing the rings, insure longer ring life and greater economy of oil, especially after the

motor has been thoroughly run in, at which point sometimes oil consumption tends to become excessive. In this piston an unusually wide band has been provided above the top ring. There are two compression rings, each $\frac{3}{32}$ inch wide. Below these rings is an oil ring, $\frac{3}{16}$ inch wide. All three of these rings are pinned to prevent their motion around the piston. Below the piston pin is an oil control ring, $\frac{3}{32}$ inch wide.

The connecting rod shown in Fig. 51 is of the splash lubricated type and is equipped with a large drilled oil dipper and an oil groove in the lower half of the bearing. It will also be noted that this particular rod is fitted with shims for adjusting.

Autothermic Aluminum Piston. Thermostatic control of expansion is used in aluminum alloy piston known as the Nelson Bohnalite piston. Autothermic Type, is standard equipment on a number of 1937 cars. The piston was used on race cars at Indianapolis as far back as the 1934 race and also with it the motor boat, Miss Canada IV, won the World's 225-Class Power Boat Championship at Toronto in 1936. This boat carried a Ford V-8 engine adapted by Bohn engineers for marine racing purposes.

The piston meets the problem of compensating for the difference in the heat-expansion coefficients of the cast-iron cylinder and the aluminum alloy piston in a novel manner. Although the high silicon-aluminum alloy of which Bohnalite "L" is representative has the lowest coefficient of heat expansion of the various commercial aluminum alloys used for pistons, the difference in the expansion rate of this alloy and cast iron is approximately 2 to 1. It is to answer the need for offsetting this 2 to 1 ratio of differences in expansion that has forced the development of the Autothermic piston which is designed to reduce skirt friction and to prevent skirt collapse and skirt contraction, the cause of piston slap during cold starts.

The piston has steel inserts or plates, as shown in Fig. 52, similar in shape to the invar struts used in a former Nelson design. These inserts are punched and formed from low-carbon steel and set into the mold in such a way that their ends are anchored in the aluminum of the skirt, but not to the piston pin bosses, as the skirt, bosses and head compose a one-piece casting, which relieves the steel inserts of thrust and inertia loads.

In the completed piston these steel strips are paralleled by aluminum over their entire length and these parallel members of steel and aluminum form a thermostatic element from which is derived the name Autothermic. Since the aluminum when heated expands more than the steel, the element will assume a curved form, tending to increase the expansion of the skirt in the direction parallel to the piston pin and to reduce the expansion along diameters perpendicular to the piston pin.

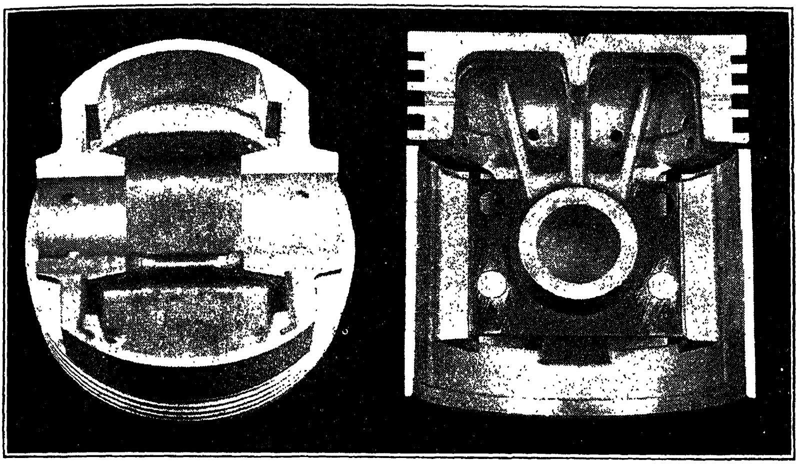


Fig. 52. Nelson Bohnalite Piston, Autothermic Type, Sawed to Show Cross Section. This is the tin-plated unit used on the 1937 Packard six.

These expansion characteristics cause a piston skirt which is of cylindrical form at working temperature in the engine to assume an oval shape at room temperature. Therefore, in manufacture, the skirt at room temperature is ground oval, and as the piston heats up in service the autothermic action causes the skirt to approach cylindrical shape without pressure from the cylinder wall, thus maintaining a close working clearance without undue friction. The degree of closeness of the working fit can be varied to suit conditions by properly proportioning the thermostatic elements.

From a weight standpoint the Autothermic piston is on a par with the all-aluminum type. A typical 3¼-inch diameter piston, for example, weighs 13.75 ounces and a 3¾-inch heavy-duty truck piston weighs 26.1 ounces. To prevent cold-scoring of the pistons,

they are tin-plated. Plating is accomplished by the immersion process, no current being used.

Owing to the fact that there are two possible arrangements of the piston pin, the skirt is made in two types—a solid-skirt type for engines in which the piston pin is clamped in the connecting rod and a split-skirt type for engines in which the pin is a floating fit in the rod.

Koetherizing Process. The American Hammered Piston Ring Company has developed a process for resizing worn aluminum alloy

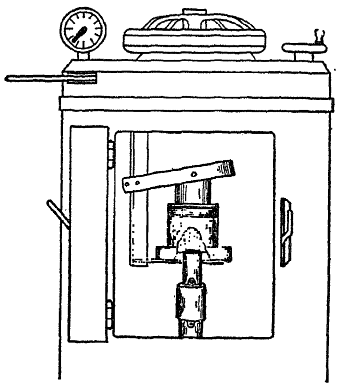


Fig. 53. Koetherizing Process for Enlarging Pistons

pistons. By this method which is termed the Koetherizing process, worn pistons may be enlarged a proper degree so that they will again fit properly into the cylinders without the necessity of installing expanders. The process consists of the application of a blast of steel shot against the two inner thrust sides of the piston, Fig. 53, skirt walls throughout their length and for a specified length of time at a specified air pressure. This hammering of the inside of the piston by the steel balls results in raising the hardness of the inner surface of the metal by increasing the density.

The density, due to the work hardening of this surface, is controlled by the velocity and force of the impact of the steel shot which builds sufficient tension into the piston metal to cause it to expand to a predetermined diameter. Thus it is possible to enlarge the old piston a proper degree to have it again fit the cylinder bore.

The tension imparted to the metal in this manner is not adversely affected by operating temperatures of the engine. Any type of aluminum alloy piston may be processed with this method. Koetherized pistons are made cam-shaped, thus permitting closer fit than would otherwise be possible. An advantage claimed for this type of piston reconditioning is keeping the original weight of the piston. It is not claimed that the process will eliminate all need of reboring where cylinders are badly worn, but in cases of a lesser degree of wearing the process will prove satisfactory.

PISTONS AND PISTON PINS

BUICK PISTONS

The pistons used in the 1938 Buick cars have a special dome shaped head, as shown in Fig. 1.

With this construction, in combination with a cylinder head of the same shape, higher compression ratios are possible. This gives a

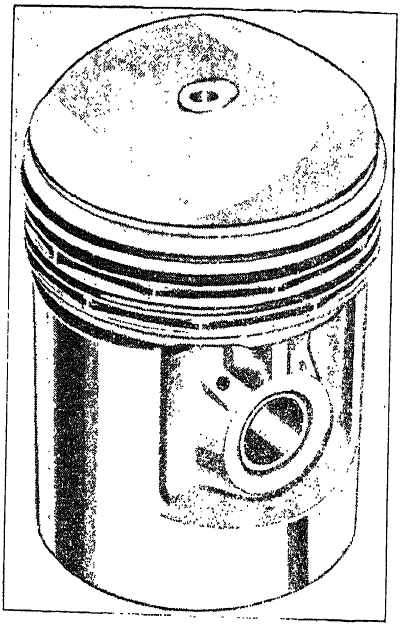


Fig. 1. Buick 1938 Piston
Courtesy of Buick Motor Co.

better control of the combustion, and spark knock is less than that found with flat head pistons using the same compression ratio.

The dome-shaped piston and cylinder head gives greater turbulence to the gases, which is a great factor in efficient combustion and fuel economy.

The pistons are made of light weight alloys heat treated and given the electrolytic treatment, which is known as the anodic treat-

ment. This oxidizes the surface of the piston, which makes it very hard and yet slightly porous, giving greater wearing quality. Oil also adheres to the surface, so that an oil film is maintained under extreme operating conditions as when starting a cold engine, or when the engine runs at a sustained high speed in high air temperatures.

A horizontal slot between the ring lands and skirt on the camshaft side and a T-slot on the left-hand side, combined with cam

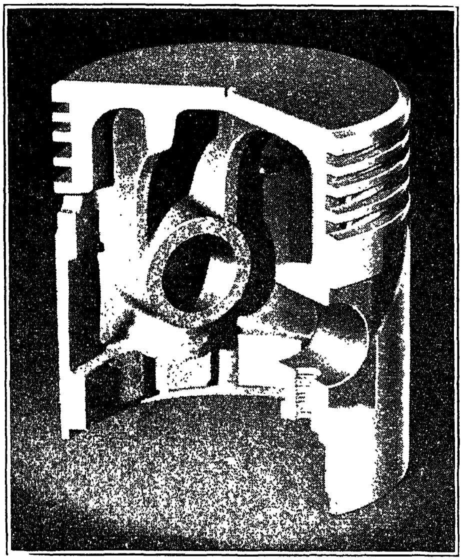


Fig. 2. Oldsmobile Piston Showing Thick Skirt and Balancing Ribs
Courtesy of Oldsmobile Motor Co.

grinding, allow the pistons to be fitted to the cylinder blocks at normal room temperature of about 70° F. This is about the same clearance which would be given to cast-iron pistons. The piston pin is locked in the eye of the connecting rod and floats in the piston. Piston pins are fitted with a light finger push fit which is about .0003″ to .0004″ at about 70° F. Pistons are selected fitted with clearances of .0015″ to .0021″ on the 40 series and .0017″ to .0023″ on the 60–80–90 series.

Clearance of course must be tested always at the point of the greatest piston diameter.

OLDSMOBILE PISTONS

The pistons on both the 6- and 8-cylinder models are electro-hardened aluminum alloy. The pistons have two compression and two oil rings, and balancing ribs on the inside bottom of the skirt as shown in Fig. 2.

Attention is called to the heavy rib at the bottom of the skirt, and the thickness of the skirt, and the double top rib. This heavy construction minimizes distortion to an extremely small amount.

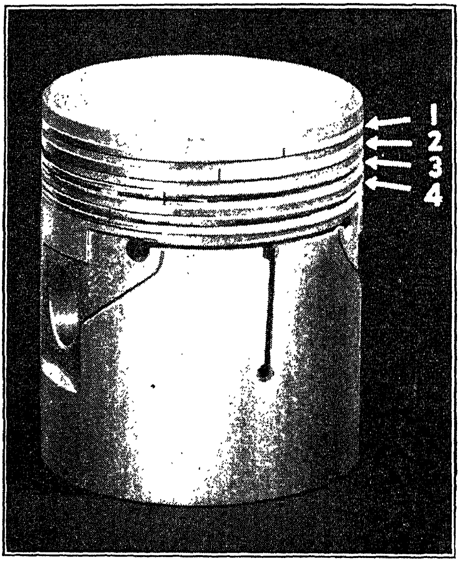
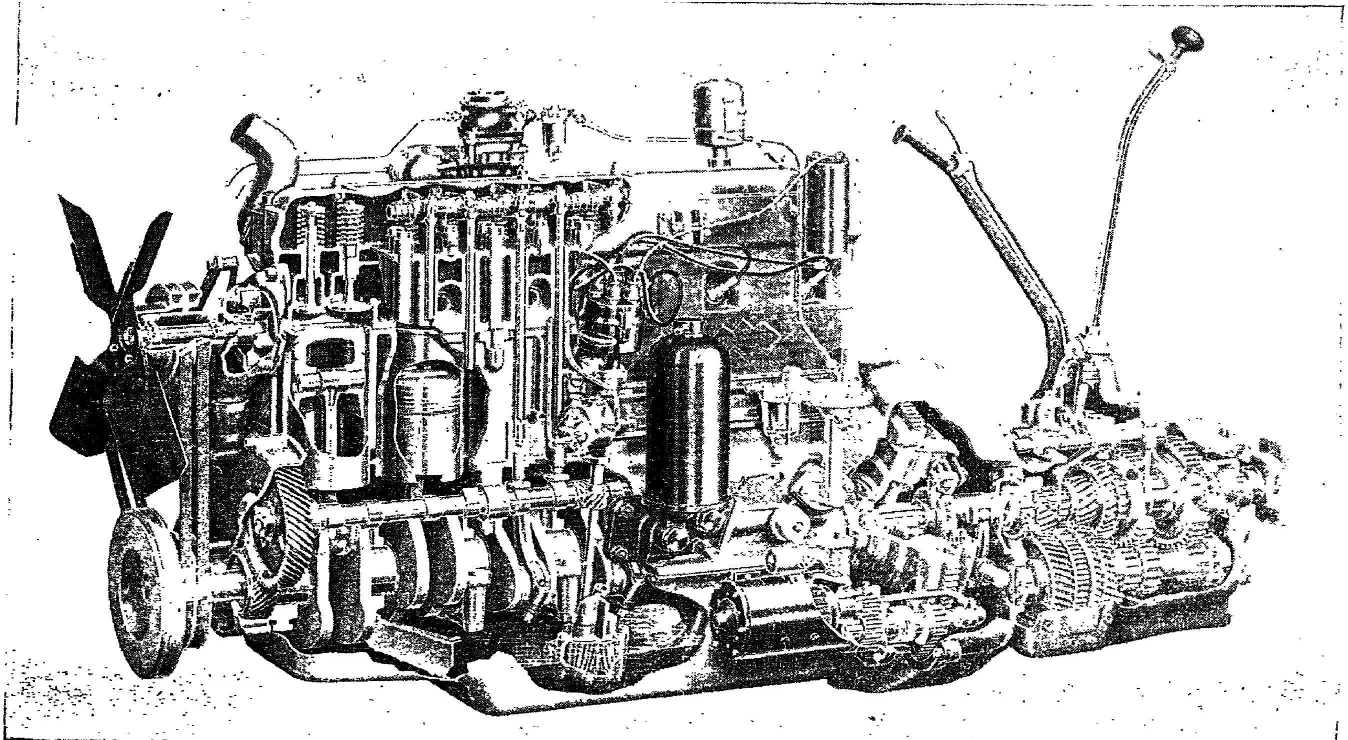


Fig. 3. Oldsmobile Piston Showing Compression and Oil Control Rings, Horizontal and T-slots
Courtesy of Oldsmobile Motor Co.

To prevent scoring, the piston is relieved at each end of the piston pin. To obtain perfect balance, metal has been added to the piston boss opposite the locking screw. Although the piston skirt is heavily constructed, it is flexible owing to the horizontal slot provided on the maximum thrust side or valve side of the piston, and the two slots as provided on the minimum thrust side shown in Fig. 3. These partly isolate the head with its thicker section from the skirt, with its relatively thin section and oval contour. These slots are backed

with reinforcing ribs and prevent collapse and assure adequate strength.

To insure adequate cylinder wall lubrication at lower speed and during the warm-up period, when there is insufficient throw off from the bearing, an oil spit hole is drilled in the upper half of the connecting rod bearing. When the shaft revolves in the bearing, this oil spit hole lines up with the oil hole in the crankshaft as the piston approaches top dead center of each piston stroke and a spray of oil is shot onto the exposed cylinder wall.



CUTAWAY OF 1946 INTERNATIONAL TRUCK RED DIAMOND ENGINE
Courtesy of Truck Division, International Harvester Company

VALVES

CONSTRUCTION AND ARRANGEMENT OF VALVES

The gasoline automobile engine is built upon the four-cycle principle, that is, valves are used to admit gases on the first down stroke of the piston, this being called the intake stroke; the valves then close and the gas is compressed as the piston is raised in the cylinder, this being called the second stroke. During the third stroke the valves remain closed. The gas is fired and as the piston is forced downward, the third stroke is under way. On the second up stroke of the piston, the fourth stroke of the cycle is completed, namely, the burned exhaust gases are driven from the cylinder. In order to control the cycle valves are provided.

POPPET VALVES

Poppet valves have proved satisfactory for the induction and expulsion of gases from the engine. All valves operate under hard conditions as operating temperatures vary from very cold to very hot, meaning that expansion of parts must be considered and valve materials must be of high quality that will not warp or burn.

With the advent of high-compression engines and higher operating temperature within the engine-cylinder combustion space, engineers found trouble with the burning of valves and valve stems, as illustrated in Fig. 1. To offset this condition special steels have been brought into use so that ordinarily little trouble is experienced. In the best practice the exhaust valves at least are made from high-grade steels which are not subject to warping or burning. Sometimes the manufacturers use another type of steel for the inlet valve, which is better adapted to service in that position. Where this is so, mechanics should be careful never to get the intake and exhaust valves mixed when servicing an engine. Austenitic steel is used in many valves. It is non-oxidizing and so non-burning.

L-Head Engines. Perhaps the simplest engine valve design in use today is that in the L-head engine. The valve and valve action on the L-head engine have not been materially changed in a number of years. The most commonly used of these appears in Fig. 2, which

shows a valve lifter of the mushroom type resting upon the cam and under the valve stem. An L-head engine is shown in Fig. 3.

I-Head Engines. The I-head or valve-in-the-head engine is also

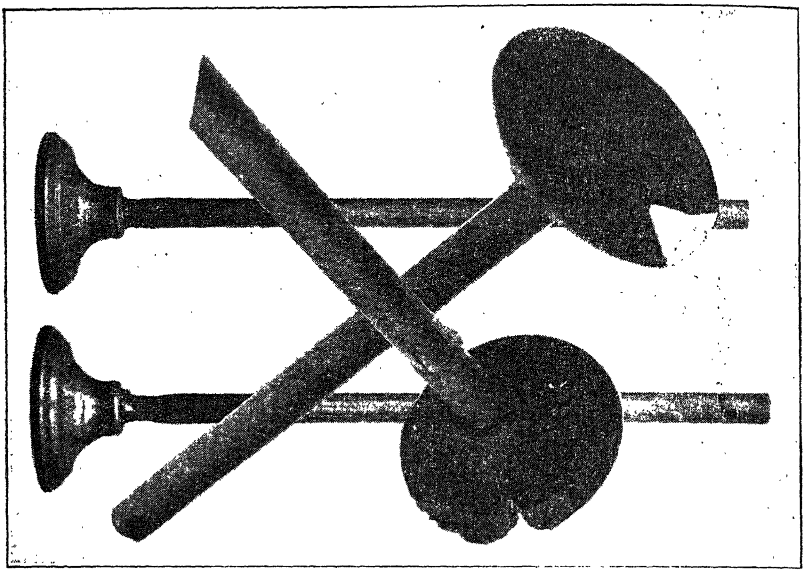


Fig. 1. Valves Burned, Pitted, and Damaged in Service

a very popular form with the manufacturers and with the public. In a general way the construction of the valve action follows the design shown in Fig. 4. This is also called the overhead valve. However, the reader will want to remember that an overhead valve may also have an overhead camshaft. In this case the camshaft and cam-follower design is very similar to that for the L-head engine, as will be noted by reference to the illustrations. However, since the valve is in an inverted position, it is necessary to have a rocker arm on the top of the engine which may be used to reverse the motion of the valve movement and push the valve down into the combustion chamber, thus opening it. In order to accomplish this, a push rod is used to connect up the outer end of the rocker arm with the top end of the push rod.

When this type of engine construction is used, the valves are set in the cylinder head instead of in the cylinder block. When

the cylinder head is removed, the valves are removed with the head. When doing a valve reconditioning operation, the work is done with the cylinder head on the bench.

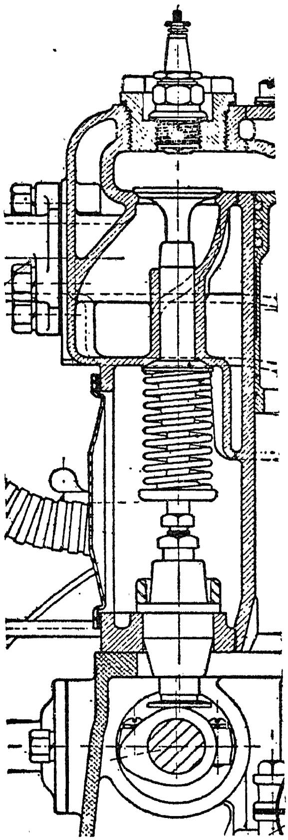


Fig. 2. Mushroom Type of Valve Action

Valve Lifters. Valve lifters are also termed cam followers. The lower surfaces of these rest upon the cam. Valve lifters are carried in valve-lifter guides, which, as a rule, are machined up separate and apart from the crankcase although this is not always true. Fig. 5 shows one method of fastening valve-lifter guides to crankcase, two of these being held to the crankcase by means of stud bolts.

Overhead Camshaft Engine. The overhead camshaft has long been popular with the foreign manufacturers and has had several

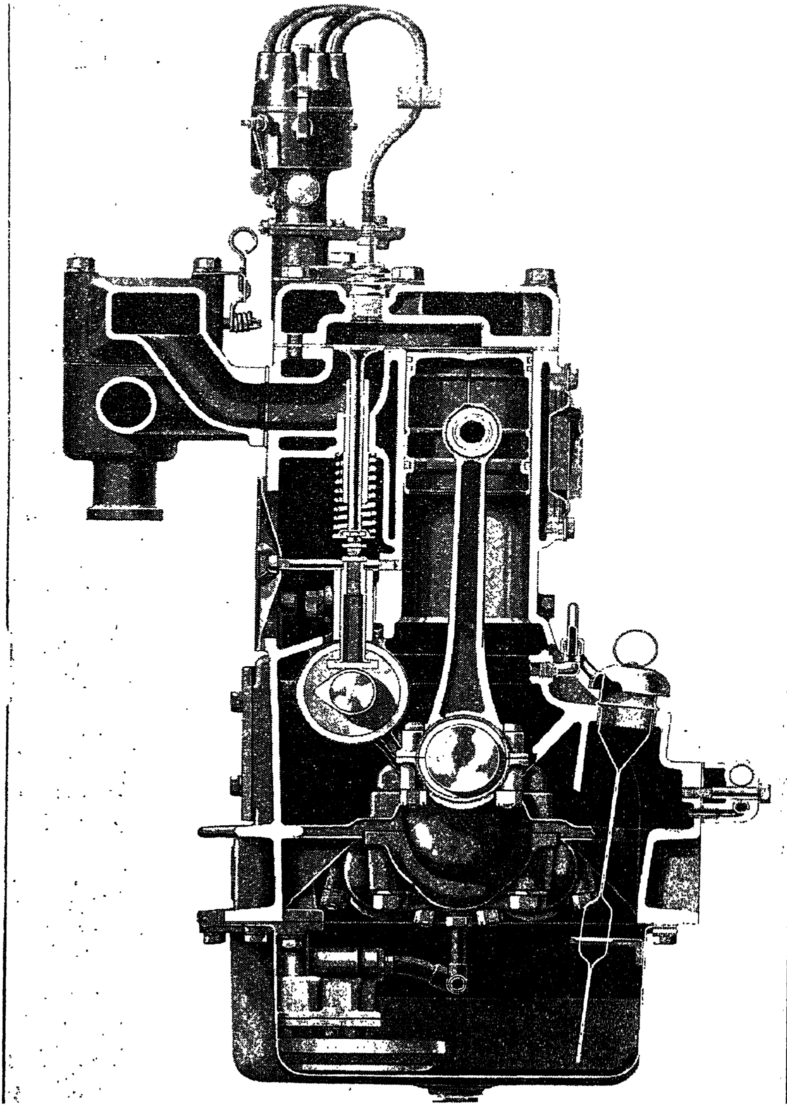


Fig. 3. Conventional Arrangement of Valves and Valve Action in an L-Head Engine

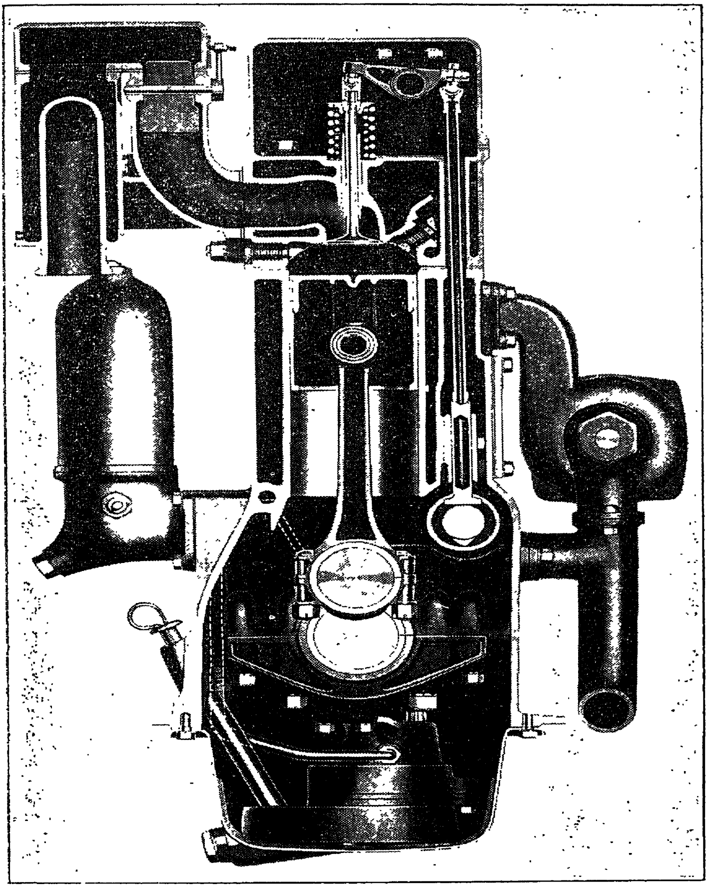


Fig. 4. Cross Section View of I-Head Engine Showing Valve Action

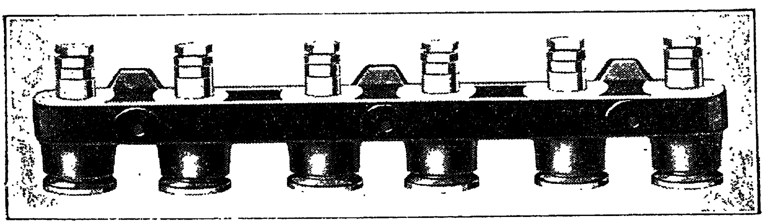


Fig. 5. Mushroom Valve Lifters in Guides

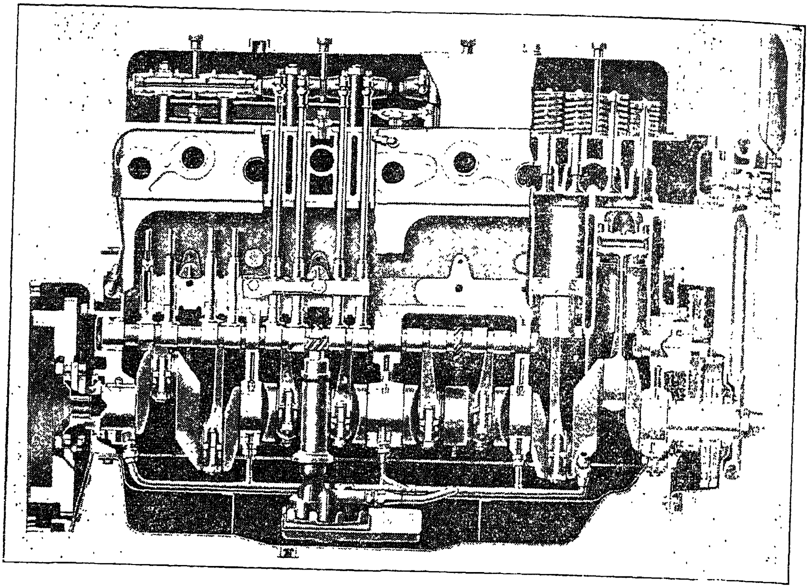


Fig. 6. I-Head Valve Action with Mushroom Type Lifters

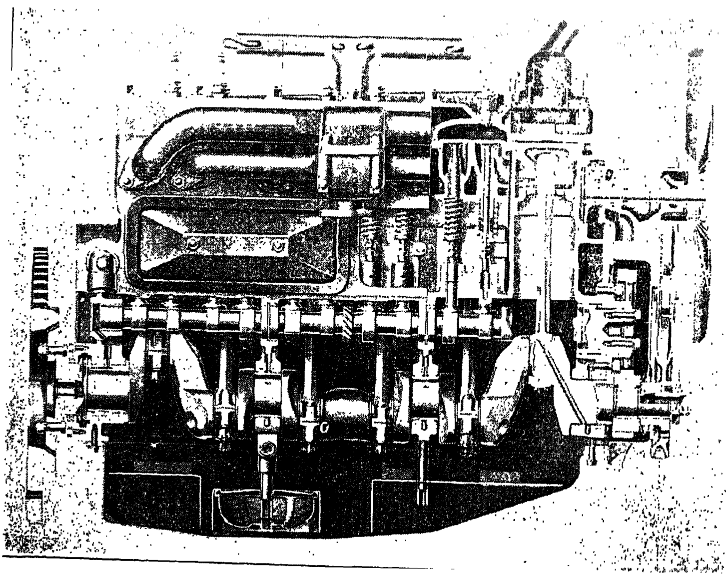


Fig. 7. L-Head Valve Action with Mushroom Type Lifters

notable successes among the American builders. The Stutz straight-eight is an outstanding example of the success of this type of construction. The Miller Racing Engine, Fig. 8, is outstanding for track performance. When the overhead camshaft is used, it must be driven by a series of gears and vertical shaft or by several chains.

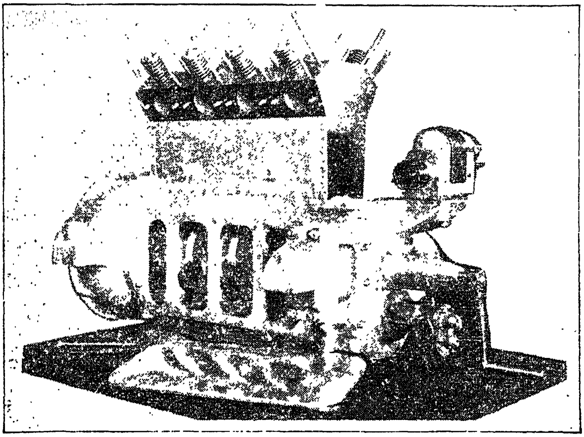


Fig. 8. Four-Cylinder Miller Racing Engine

INSPECTING AND SERVICING VALVES

It is doubtful whether there is any point about the automobile engine which requires as much attention and service as the valves. Fortunately this is a part of the repair man's service work which does not involve a great deal of expense for the customer. It does offer a steady source of revenue. There is more to reconditioning valves than would appear on the surface. Engineers have made a study of the problems involved in servicing valves and the operations listed are those commonly accepted as being best practice. The equipment at hand will indicate the method to be followed.

Certain fundamental facts must not be forgotten in servicing valves. A valve seat may not be too wide. The valve stem must not be warped or bent. The valve guide must not be worn too much nor must it fit too closely. Valve springs must have the proper tension. The valve tappet and valve stem clearance must be according to manufacturers' specifications. The valve action must

be in time with the piston travel. The valve ports must be kept free of all accumulation of carbon. These are some of the main considerations in servicing valves.

Checking and Adjusting Valve Clearance. Customers driving their cars into service garages very frequently mention the fact that the valve tappets are noisy or they may complain about one particular valve tappet being noisy and giving off a very disagreeable knock. As a rule when this complaint is made, it is evidence that some one tappet adjustment has become disarranged and that that particular tappet which is giving out the noise has more clearance than the other tappets. This is not always the case. It sometimes happens that a valve tappet has been set up too tight and the cam and cam follower have become scored, worn, or otherwise damaged. If the original adjustment of the tappet or lifter to the proper clearance does not eradicate the trouble, look for a spinning valve lifter or one which is scored and has loose rollers and pins, or similar conditions.

The thickness gauge, shown at *E* in Fig. 9, is used by mechanics for testing the clearance between the valve stem and the valve lifter, as shown at *D*, and between the valve rocker arm and the end of the valve stem, as shown at *A*.

Valve clearances are specified by all car manufacturers. Usual practice with reference to L-head engines is to give the valve lifter on the intake valves .004-inch clearance. The valve clearance on the exhaust valves is usually .006 inch. The larger clearance is allowed on the exhaust valves with the assumption that when the engine is heated up, the clearance in each case will be approximately the same. If this be true, then it is also true that if the engine is hot when the adjustment is made, all valves should be set with a clearance of .004 inch.

Clearance allowed for valve lifters in the case of overhead valves is usually more than that allowed for the L-head types. Not less than .006 inch should be given to the intake valves and not less than .0C8-inch should be given to the exhaust valves. The clearance for valves on the overhead valve engines sometimes runs as high as .015 inch in certain models. When the mechanic is in doubt, he should consult the instruction manual with reference to the particular engine being serviced.

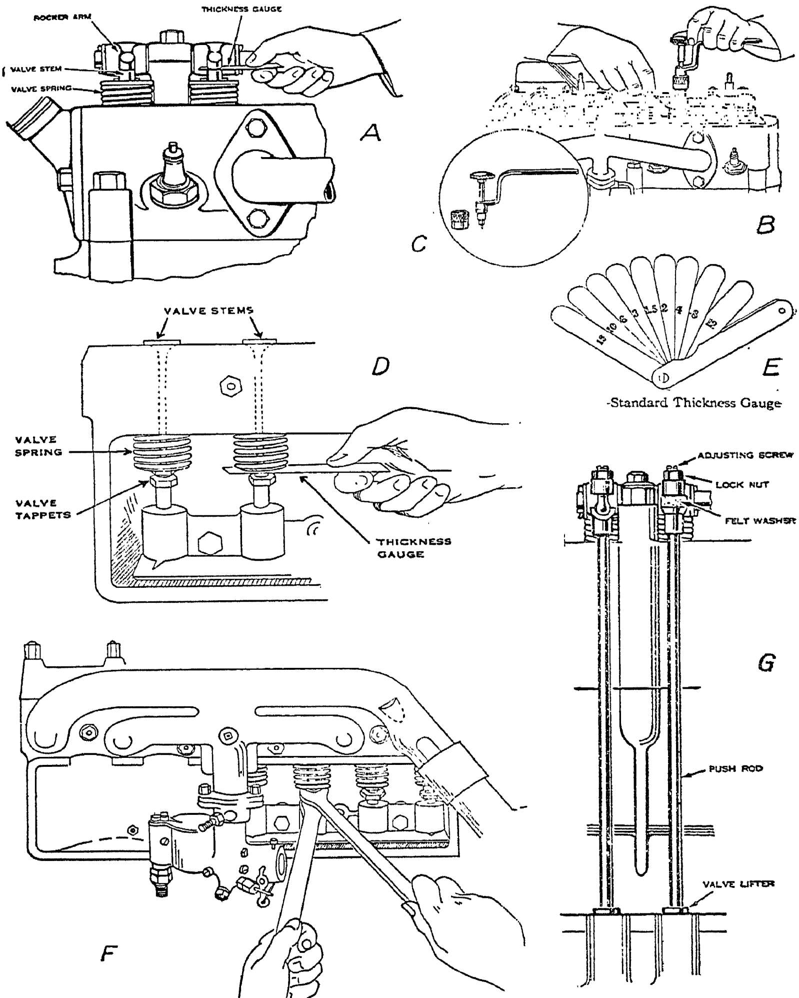


Fig. 9. Testing and Adjusting Valve-Stem Clearance

The construction of the Chevrolet push rods and rocker-arm assembly with reference to the adjustment of the valve clearance is very similar to that of most overhead valve engines and is shown at *G*, Fig. 9. There is a lock nut and an adjusting screw provided so that by loosening the lock nut and turning the adjusting screw the correct clearance may be secured, and it can be maintained by locking the lock nut. A special tool used for doing this work in the case of the Chevrolet engine is illustrated at *C*, Fig. 9, and its use is illustrated at *B*, the mechanic using one hand to adjust the clearance while testing it with a thickness gauge in the other hand.

In the case of the L-head engine from two to three tappet wrenches are required. In the case illustrated at *F*, Fig. 9, but two are used. In this case the valve lifters are secured against turning in the valve guides; but if the construction is such that the valve lifter may turn, then an additional wrench is required to keep the valve lifter from turning while another wrench is used to loosen the lock nut and the third or top wrench is used to turn the adjusting screw in or out to secure the desired clearance.

Make very certain that all valves have exactly the same clearance. If the valves have a tendency to burn, provide them with more clearance. If they are noisy and the customer complains of the noise, they should be set up a trifle closer. Under no circumstances, however, should they be set so close there is no clearance left when the engine is as hot as it is likely to get under hard service—that is, there should not be less than .002-inch clearance under the hardest possible service. If such a condition should exist, serious damage is likely to arise. When no clearance remains, the valve then rests on the top of the adjusting screw; and when the explosion occurs within the cylinder, there is a very great force driving the valve down onto the camshaft, with the result that parts will be damaged. Usually this results in scoring of the cam and cam followers or it may result in broken cam rollers and pins. In the case of engines where considerable trouble is experienced with burned valves, the chances are the trouble is due to too close valve tappet adjustment or valve-stem clearance.

Removing Cylinder Head. A careful mechanic always gives thought to the draining of the cooling system before placing the car on the block, for the system may be drained and then the car

driven to position, this small amount of driving doing no harm and warming up the cylinder to the point where some of the water remaining after draining may be evaporated and driven out in the form of steam. Carefully disconnect all hose clamps and remove

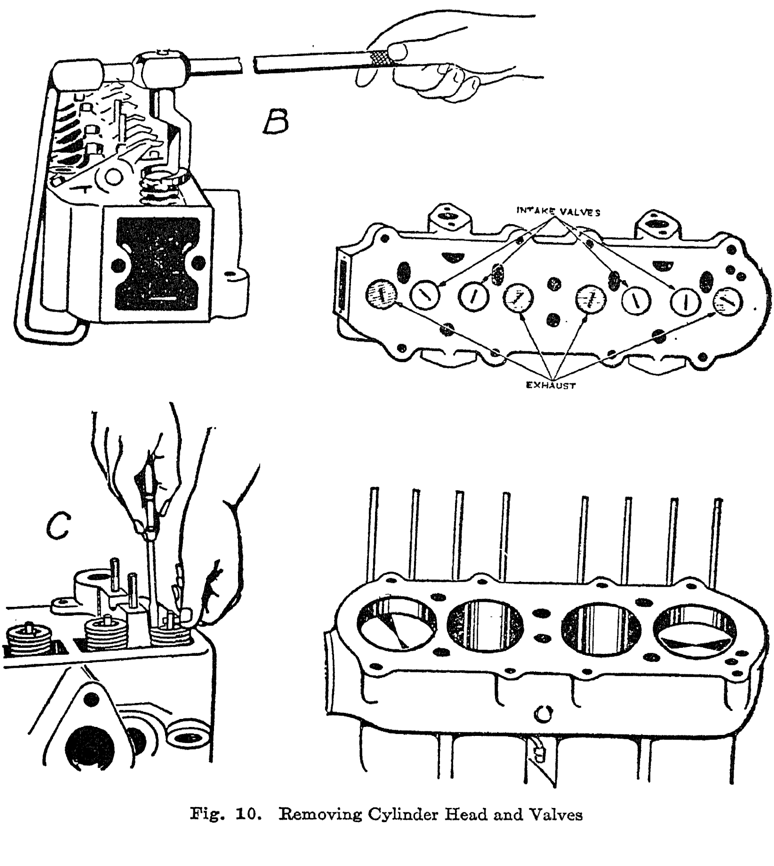


Fig. 10. Removing Cylinder Head and Valves

all other connections which would interfere with lifting off the head. The next point is to remove the cylinder-head stud bolts or the nuts locking the cylinder head in position, as the case may be.

Many cylinder heads are damaged permanently by the untrained and careless mechanic when attempting to remove the head after the stud nuts have been removed. Instead of using care to

see that the gasket is preserved and the head left free from defacing marks they will use a cold chisel or screwdriver to drive between the head and the cylinder block. In certain cases manufacturers provide bosses on the cylinder head and cylinder block between which the pry bar may be placed, but this is not universal practice and does not condone the use of tools which damage the machined face of these parts. If trouble is experienced in breaking the head loose, the best practice is to simply back off the cylinder-head nuts about three or four turns, leaving them all in that position. Do not remove spark plugs. Use the hand crank to turn over the engine and it will be found that the compression will break the cylinder head loose, lifting it up against the backed off nuts. After it has been loosened thus, the nuts may be removed and the head can easily be lifted away from the cylinder. This practice will also result in saving the cylinder-head gasket in the best possible condition and this sometimes is a very vital consideration, especially in out-of-the-way places where new cylinder-head gaskets may not be so easily secured.

After the cylinder head is removed, it is placed on the bench where it may be cleaned. If the head contains the valves, the valve servicing operation may proceed. Fig. 10 shows the Chevrolet four-cylinder head after it has been removed. At *A* is shown which are intake and which are exhaust valves. One method of removing the valve springs and lock washers is shown at *C* and is the commonly followed practice where not a great many Chevrolet cars are serviced. Push down on the screwdriver and thumb until the valve pin is exposed, after which it may be removed. An easier way of doing this work is with the valve spring compressor, shown at *B*. This is a special tool designed for this service and one which should be in the hands of every mechanic who expects to do a great deal of this type of work.

Cleaning Carbon. The amount of carbon which will accumulate within the combustion chamber of the engine is variable. The number of times the engine may have to be taken down to have carbon removed will have to be determined by the general operating characteristics of the engine under consideration. The fuel used has a very great influence upon the accumulation of carbon. The condition of the rings and cylinders is another important factor.

If an engine is pumping oil, there is only one way to dispose of the surplus oil and that is by burning it. Burning it leaves carbon. If not burned, it will be in a moist and gummed state. If the engine is firing satisfactorily, the carbon will be dry and hard. A condition similar to the latter was evidenced in the engine combustion chamber as illustrated in Fig. 11. The carbon in this case was approximately $\frac{1}{8}$-inch thick. The piston is illustrated with part of the carbon removed and showing the depth of it.

The novice has an idea that all the carbon which accumulates in an engine is that which appears when the cylinder head is lifted off. This is far from being the case. As a matter of fact, outside of the disagreeable knock which occurs, this particular carbon may not do any damage. It is the carbon which is not visible which does the damage. For instance, carbon will collect around the piston rings, particularly in the groove back of the ring. Sometimes it collects until the ring is locked in the groove, after which scoring of the cylinder walls is only a question of a short time.

Carbon also collects within the valve ports and under the valve heads, as shown in Fig. 11, and in the exhaust manifold and the muffler. In the latter case the engine may operate very erratically and unless the service man is one of considerable experience, he will not think to look at this point to learn the cause of unsatisfactory operation. When carbon collects within the exhaust manifold or muffler to the extent that the free exhaust of the burned gases is interfered with, the power of the engine is materially lessened. Many cases are on record where an engine will actually stop from this accumulation, and mechanics have won the undying gratitude of the car owner when they were keen enough to discover this and restore the car to its normal power. Another point which is seldom thought of is the inside of the piston. This is more likely to happen in cast iron than in aluminum pistons since aluminum pistons conduct the heat away more readily. However, this is a point to be taken into consideration when rebuilding an engine. A piston which was cut in two showed the amount of carbon which had collected was $\frac{1}{4}$-inch thick under the piston head. The piston was weighed before cleaning and after cleaning. Exactly two ounces of carbon were removed from it. It will be understood that unless a similar amount of carbon had collected on each piston, the engine would

be out of balance and would give off a great deal of vibration, when operated.

Formerly carbon was removed by means of a screwdriver, putty knife, or what was termed a carbon scraper. These scrapers

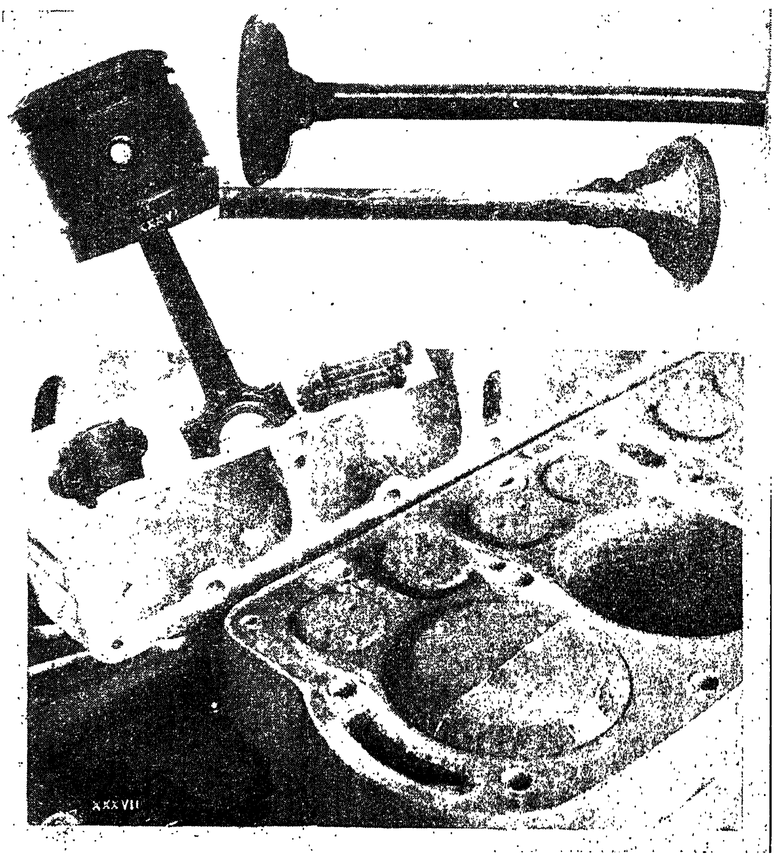


Fig. 11. Carbon Accumulation on Valves, Cylinders, and Pistons

were nothing more than cold-rolled steel, flattened out on one end and provided with a handle on the other. The steel brush has been found a very great aid in removing carbon. If no electric drill is available, the hand brush with steel bristles can be used to great advantage after the hand scraping has been roughly fin-

ished. Possibly the most rapid method of removing carbon is by means of a small brush as illustrated in Fig. 12 and used in connection with a $\frac{1}{4}$-inch electric drill. These brushes are made with stiff bristles so that they will actually cut into the corners and dig off the carbon out of the piston or cylinder head. They leave the parts polished bright, and carbon deposits do not form so readily as they would if the job were only partially cleaned. Many of the larger shops are using an electric motor in connection with a flexible shaft on which the wire brushes are mounted for this work.

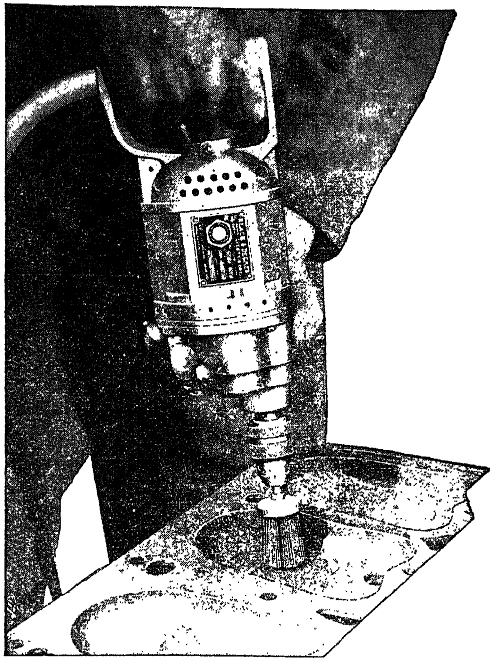


Fig. 12. Using Electric Drill and Wire Brush to Remove Carbon from Cylinder Head

Removing Carbon by Burning. In removing carbon by burning, a spark is first applied to a mixture of carbon and oxygen and then combustion takes place. The carbon will continue to burn until it is completely exhausted or until the supply of oxygen is cut off.

The engine should be turned by the crank until piston *1* is on upper dead center, ready to fire. The spark plugs are then removed and a little oxygen allowed to escape from the torch into the combustion chamber through the spark-plug hole. This is done so that there will be sufficient oxygen to support combustion when a match is dropped through the spark-plug hole before the oxygen torch is inserted. After the regulator, Fig. 13, has been adjusted to a pressure of about 15 pounds, the torch nozzle is inserted through the spark-plug opening, which causes the carbon to burn very rapidly.

It is important always to have at hand a reliable fire extinguisher as some sparks or hot carbon may drop in the oil pan and cause a fire. It is unnecessary to turn off the gasoline supply to the carburetor or to remove the carburetor, as the closing of the inlet valves prevents any chance of a fire in this instrument.

Keeping Track of Valves. It is essential that valves be properly marked or else some means be provided to keep them in order. For instance, the first valve at the front of the engine is always No. 1 and the next No. 2, and so on back to the rear of the engine, there being either eight or twelve valves ordinarily—sixteen of course in the case of the straight-eight. In the case of the V-type engine, the valves are numbered from the front of the engine back—1-R for right and 1-L for left, and so on. The usual form of marking is to stamp with a steel numeral. If one is not at hand and the valves are not marked, a center punch may be used, punching one center punch mark on the first valve, two on the second, and so on. When new valves are installed, it is also desirable to mark them so they may be kept in order. Not all poppet valves lend themselves to the marking process for the simple reason that they are glass hard in some cases. Where this is the situation, the use of the valve board, similar to that in Fig. 14, is suggested. Simply take a strip of wood, approximately 1 inch x 2 inches in cross section, and bore or drill a number of holes in it to receive the valves. One end of this is marked for the front and then starting from this the first valve goes in the first hole, etc. The splendid feature of this method, in caring for valves, is that the valves may be carried about the shop without having them mixed and the valve desired may be picked out without loss of time.

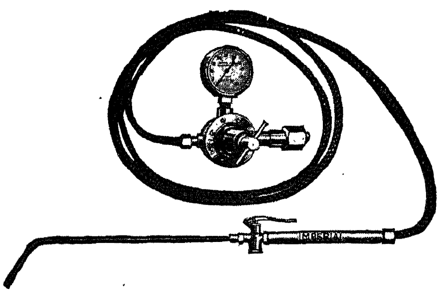


Fig. 13. Oxygen Regulator for Carbon Burning

Removing Valves. Possibly more tools have been invented for the mechanic to use in removing valves than for any other part of the engine which requires service. These are of all types and of varying value. In some cases engines require specially designed

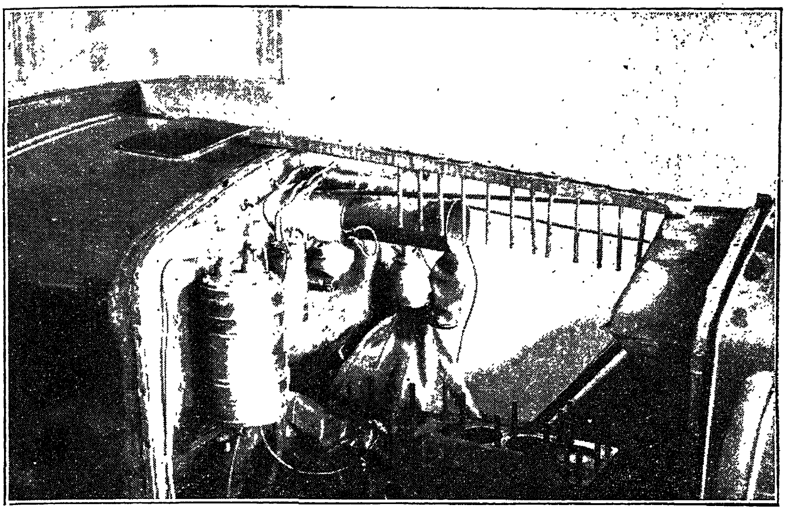


Fig. 14. Use of Valve Board to Keep Unmarked Valves in Order

valve lifters. A very effective one is shown in Fig. 15. This lifter, when the valve spring is compressed, will hold it in that position without attention on the part of the repair man, as will be seen at a glance at the illustration. There are certain valve lifters which are designed to compress the spring when it is in position in the engine and then a small clip is provided which slips over the spring and holds it in a compressed position until it is finally replaced in the engine. This is a very desirable feature when working in close quarters.

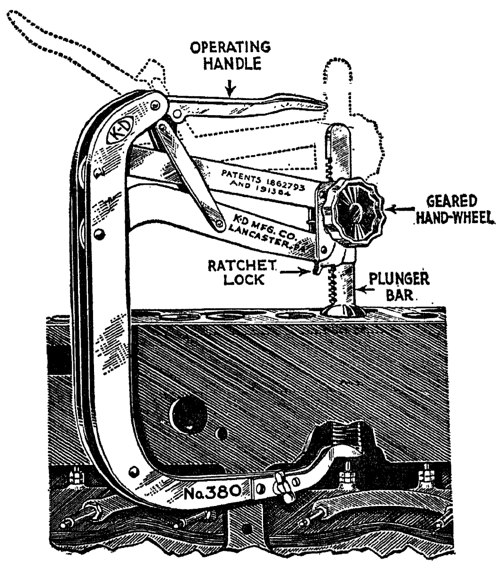


Fig. 15. The K. D. Ideal Compressor for General Garage Use

When removing valves, extreme care must be used to prevent the valve retaining key or lock, as the case may be, from dropping into the crankcase. Many engines are not provided with a screen or partition between the lower end of the valves and the crankcase itself so that if a valve spring retaining lock is dropped, it is lost within the crankcase. In certain engines, parts move so closely that it is not

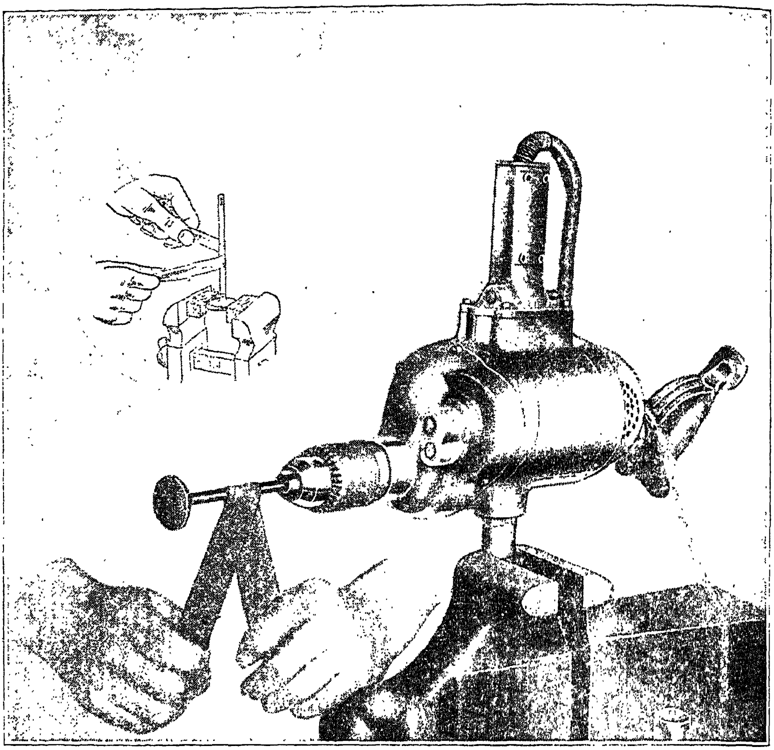


Fig. 16. Cleaning Valve Stems with Electric Drill and Emery Cloth
Cleaning Valve Stems by Hand (Inset)

desirable to have these small parts left within the case if they should happen to drop there. This means that their removal will require the removal of the oil pan, which in itself is a job requiring no small amount of time and for which the customer should not be charged. When purchasing valve lifters, it would be well to consult the automotive jobber to learn the latest development for the type or class of work which is to be done.

Cleaning Valves. After the valves have been removed, the first thing to do is to take them to the bench, drill press, or lathe and clean them. If they are to be cleaned by hand, the valve head should be gripped as shown in the inset in Fig. 16. Do not grip the valve head with the jaws of the vise but protect the head by means of two blocks of soft wood. The valve stem may then be polished by means of a strip of emery cloth. This may be purchased in strips of 50 yards to the roll or may be torn from a sheet. The carbon under the valve head, such as the accumulation which appears in Fig. 11, should be

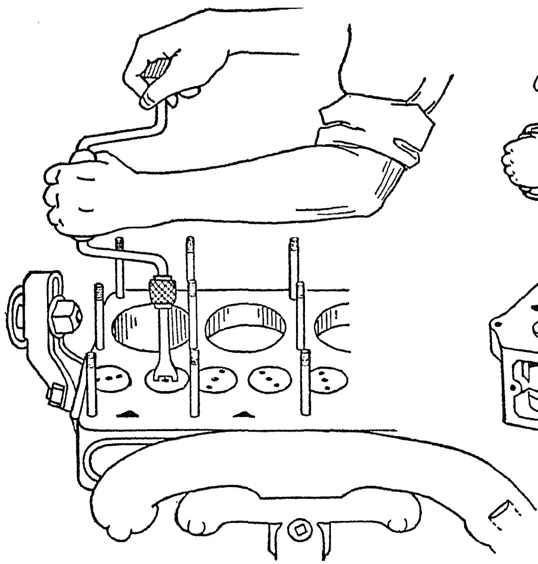


Fig. 17. Grinding Valves by Hand

scratched away by means of a pocket knife. The final job of polishing should not be circular, as shown in the inset of Fig. 16, but should be with the axis or length of the valve stem. Experience has shown that a few strokes with the emery cloth, up and down the valve stem, will remove the cross scratches produced by the circular motion and leave the valve stem in better condition for long service, both as to condition and accumulation of carbon. When the electric drill is used, the valve is gripped as shown in Fig. 16 and polished as it is rotated. Here again the emery strip is used. The same method may be used with reference to the drill press or lathe, it being only a

question of what equipment is at hand for this operation. Polish the head on top and polish the under portion as well as the valve stem.

If no special valve face reconditioning equipment is available, the mechanic will very often face the valve head with a file, while it is held in the chuck of the lathe, drill press, or electric drill. This is an operation requiring some skill to get a satisfactory job. Use a fine-cut mill file, passing it over the face of the valve as the valve head is rotated under it. Make very certain to maintain the exact angle of the valve face, that is, do not round it or change it. Continue the filing operation until no evidence of a groove is left in the valve face.

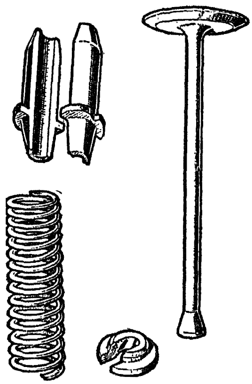
Grinding Valves. For many years valve grinding was a hand operation. This is still a very satisfactory method of doing the work with the exception that the amount of time it requires is prohibitive with some flat-rate schedules. Fig. 17 shows the most commonly used tools for this hand grinding, being on the order of a bit brace. The L-head engine at the left of this figure has valves provided with two drill holes. A special valve grinding tool is used to fit these holes. The valve-in-head engine at the right has the valves provided with a slot. A screwdriver bit is used in this case.

Many of the older mechanics preferred the use of a large screwdriver for valve-grinding work. When it is used, it is rotated between the two hands. The larger the screwdriver the more leverage is secured and the easier the work.

In order to speed up the work of valve grinding when it is done by hand, a small spring, which may be easily secured around the average machine shop, is dropped into the valve port over the valve guide and under the valve head. This is done so that when the pressure is released from the screwdriver or other valve grinding tool, the valve head will be raised from its seat. This will allow the valve grinding compound to drop into position so that it will be more effectively used. The actual grinding operation is one of rotating the valve head a half or three-quarter turn—not a full turn. After giving two or three strokes to the valve head, it is then raised on the spring and turned a quarter or a half turn before it is dropped into position again, after which the grinding proceeds. This method will prevent scratches which would run completely around the valve head and at the same time will average up the grinding operation so

that all parts of the valve face and valve seat are treated equally in the grinding operation, thus resulting in the best possible valve seat for the condition of the parts.

Grinding Ford Model "A" Valves. The Ford Model "A" valves are not provided with any slot or valve tool holes. This requires the use of a vacuum cup valve grinding tool, such as illustrated in Fig. 18. The operation is exactly the same outside of the fact that no spring need be used since the valve is held to the valve grinding tool by means of suction or vacuum and lifting on the valve tool will lift the valve from its seat.



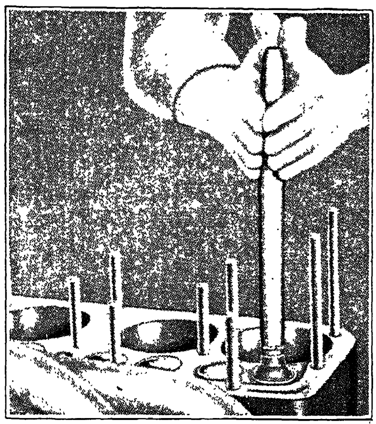


Fig. 18. Left —Ford Model "A" Valve, Valve Guide, Spring, and "Horseshoe"
Right—Grinding Ford Model "A" Valves or other Valves not Provided with Valve Tool Grips

Valve Grinding Compounds. There is a great variety of opinions among mechanics as to the proper valve grinding compound to use. This does not refer solely to the grade of compound—that is, coarse, medium, or fine—but it refers more specifically to whether the compound is an oil-mixed compound or a water-mixed compound.

It is generally conceded that the water-mixed compounds are somewhat faster cutting. On the other hand, some mechanics complain that they are a bit more difficult to remove from the valve, valve ports, and cylinder parts. Therefore it is best for the mechanic to try out the various compounds offered to the trade and learn those which he himself prefers to use.

Compounds are sold in what is known as coarse, medium, and fine grades. If an electric valve reconditioning tool, such as a refacer or reseater is available, it is not likely that the coarse grade will find any call. As a matter of fact there are many cases in which no valve grinding compound whatever is used. When valves have been reconditioned by other means and are found to be a bit faulty, the mechanic may wish to touch them up with the fine grade of compound. This operation requires just a few seconds. Be sure to clean out the valve grinding compound or abrasive material from the moving parts of the engine. Under no circumstances should any grains of the abrasive be allowed to remain within the

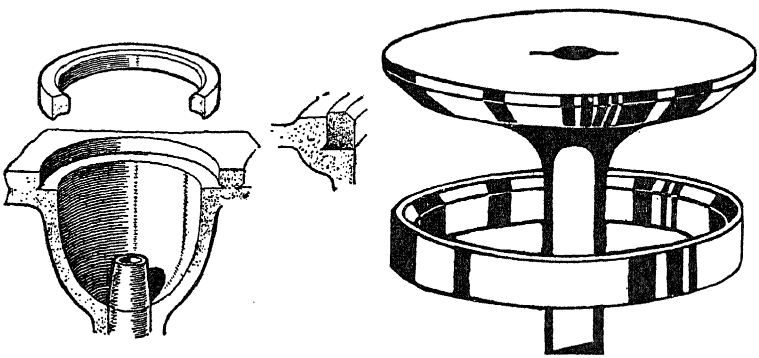


Fig. 19. Valve Seat Insert for Cast-Iron Cylinder Block

valve guides or about the valve ports. It is even more important that no portion of the valve grinding compound be allowed to sift into the cylinder and piston ring grooves. Sometimes when reconditioning valves by means of the valve stone, too much oil will be used and it will work over into the cylinder, carrying with it certain abrasive particles. The mechanic should be on the watch for this and not permit it. It is not ethical to permit anything to happen to an engine in your charge which will cause damage to that part after it leaves your shop.

Valve Seat Inserts. High compression engines operating at high speeds cause wear of the valve seats when these are machined

in the cast-iron cylinder. Some engine builders use valve seat inserts similar to the one shown in Fig. 19. Other engines, which have been subject to wear, may be repaired by first boring out for the valve seat insert. Install the insert by first chilling it with "dry ice," or salt and ice, and forcing it home quickly. The expansion of the chilled insert then serves to lock it in place. Inserts are made from hard steel alloys so as to resist wear and burning.

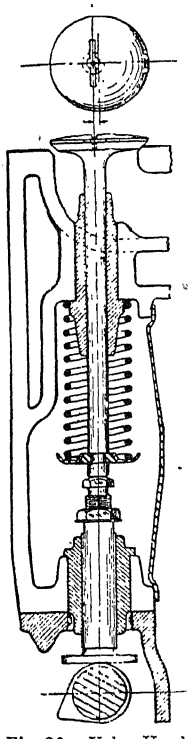


Fig. 20. Valve Head Off Center of Stem Will Not Seat Properly

Installing Valve-Seat Rings. There is cause for failure of the valve seat. After reconditioning the valve seat several times, it may be found that there is not sufficient metal left to do a good job. Under these circumstances it is very necessary to install oversize valves (referring to the diameter of the head) or it is necessary to ream out the cylinder block and install a new valve seat. These valve seats are made of high-grade steel and are in the nature of a small ring about 3/16 inch square in cross section. When installing these, a special tool is needed with which to ream out the cylinder block. The valve ring is made about .002 inch to .005 inch oversize and a special form of driver is used when installing the ring into the reamed block. After it has been driven home, it is reamed and faced just as for any valve reseating operation.

Another condition which is very troublesome and very hard to locate at times is illustrated in Fig. 20. It will be noted here the valve stem is off center with reference to the stem, which had one side only seating. Such a condition might exist if the valve stem were warped or bent and the valve was reconditioned in a valve regrinding tool. For this reason it is very important that a test or check-up be made on valves before regrinding them or reconditioning them in such a tool or machine as shown in Fig. 22.

Testing Valve Stem and Head for Straightness. After a valve has had considerable service in an engine, it may be worn until

the head is no longer true with the stem. The valve head may have become burned until it is lopsided or the valve stem may have been warped, resulting in a similar condition. In order to prevent trouble with the valve after reconditioning, it is a good plan to place it in the drill press, electric drill, or preferably in the lathe, as shown in Fig. 21 and make a check on the truth of the valve stem and also see how the valve head turns. If it is not straight, the test gauge set-up will show the exact amount of variation and allow the workman to straighten the valve stem by striking it a bit with a soft metal hammer; sometimes a rawhide hammer is used

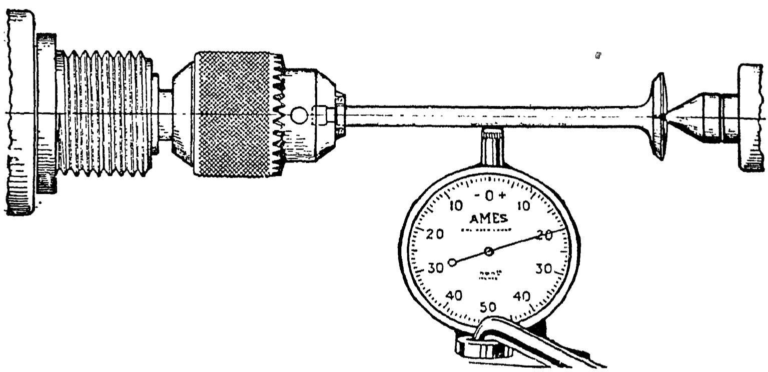


Fig. 21. Testing Valve Stem in Lathe

for this work. The condition hard to correct is when the valve head is warped. Using a soft-faced hammer and driving on the high portion of the head, it is possible to bring it into condition again. This will require considerable thought and extreme care.

Refacing Valves with Electric Grinding Machine. Regrinding valves by hand won early favor because of the simplicity of the operation. This method has certain drawbacks. In the first place if the valve face and seat are not truly concentric, repeated grindings are not certain to remove this fault. The valve may fit in one position and as it turns about on its seat will leak in other positions. Another trouble with this method of reconditioning valves is the length of time required when the valve face and valve seat are in bad condition, such as warped, burned, pitted, or otherwise damaged.

The automotive equipment manufacturers have produced a number of machines designed to speed up the work of valve-face reconditioning. The most successful of these are the electric valve grinders, such as illustrated in Figs. 22 and 23. The principle on which these machines operate is similar to that of grinding an item in the lathe with the tool-post grinder. The valve is mounted in the chuck of the electric grinder, which chuck is driven by means

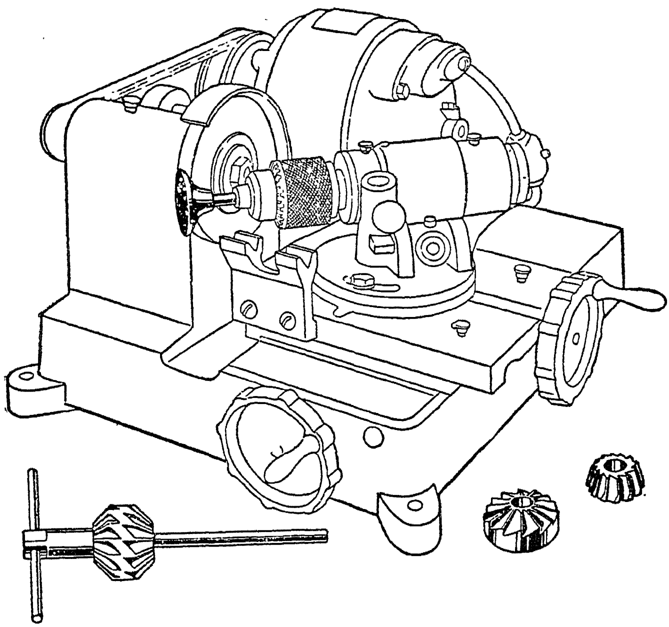


Fig. 22. Electric Valve Refacing Machine with Valve Reseating Cutters (Chevrolet Practice)

of an electric motor. Sometimes this motor is separate from the one driving the grinder head and in other cases the same motor is used for both. The grinder head is driven at high speed so that the small wheel will give a smooth cut. The machine is so designed that the grinder wheel may be fed against the face of the valve, which is rotating at a comparatively slow speed. It will be seen that by this method the valve head will be ground concentric with the valve stem and if the machine is operating properly, there will be no chatter marks on the face of the valve, it being perfect.

When using these machines, it is very essential that the grinding stone be dressed by means of a diamond-point tool so that it is always in a free cutting as well as a true face condition. Bearings must be mounted so that there will be no chatter.

Before starting the grinding operation the valves should be grasped in the chuck and turned over by hand so see whether it is running true, or this test may be made between the lathe centers. It is poor practice to start grinding on the valve face before checking

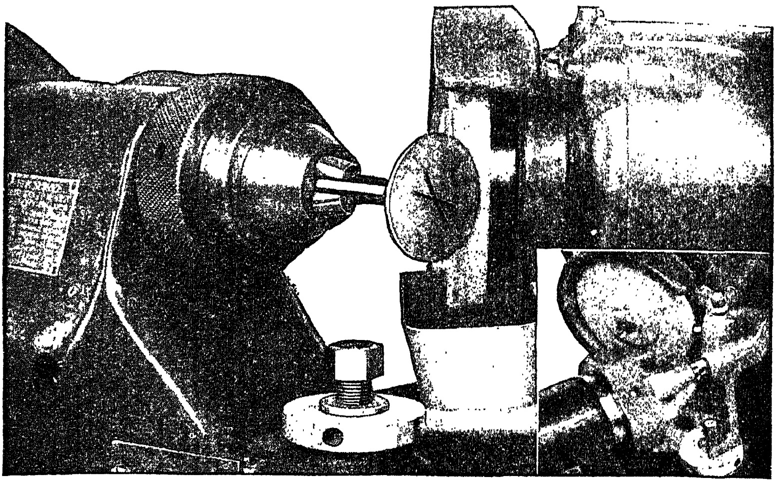


Fig. 23. Refacing Valves with Electric Grinder (Black and Decker Practice)

it to see whether it is true, as in many cases valves will be ruined by that process since the high spot will be ground away and then when the low spots come in the valve head is too small. On the other hand, if the valve has been brought true with the stem and the stem itself is true, the head may be reconditioned without removing any excess amount of metal.

Refacing Valves in Lathe. This is a very common method of refacing valves and is used by those repair men who have no electric valve grinding machine but who do have a lathe. The valve is chucked by means of the drill-press chuck, the universal, or the four-jaw chuck. The head is supported on the dead center of the tailstock. Set the compound rest so that it will cut at the angle of the

valve face, which is usually 45 degrees. While rotating the valve at a fair speed by means of the lathe, the round nose tool is fed across the face of the valve. Use a fine cut so as to secure a uniform face.

Those shops which are equipped with the tool-post grinder may use this tool for refacing valves. When this is done, the valve is mounted as shown in Fig. 24. The lathe spindle is rotated at an average slow speed. The tool-post grinder, of course, drives the grinder wheel at a high speed, giving very much the same condition which is obtained by means of the electric valve grinding machine, as shown in Fig. 23.

Refacing Valve Seats. Fig. 25 illustrates the use of a special grinding wheel or stone in connection with a high speed ¼-inch

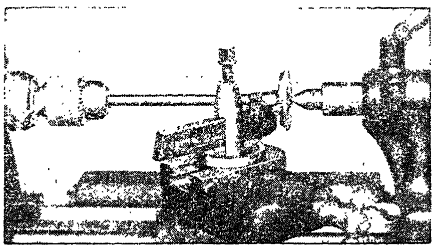


Fig. 24. Refacing Valves in Lathe
(South Bend Practice)

electric drill for refacing valve seats in the cylinder block or in the cylinder head. These stones are designed in varying sizes for meeting the varying conditions in engine reconditioning. The grain of the stone is fine so that the resulting work is of a high quality. In using, a very light pressure is placed on the tool and in order to insure free, rapid cutting, a short length of rubber hose, such as radiator hose, is placed over the cutting stone and the operator places a liberal quantity of kerosene on the rotating stone. The hose prevents the kerosene being thrown about.

To insure proper results with a device of this kind, the valve guides should be cleaned before doing the refacing work. The valve seat must not be ground more than is absolutely necessary. The grinding stone, which is made with an angle of 45 degrees, as a rule, on the grinding face, must be mounted and used with ex-

ceeding care. The face must be dressed in the electric valve grinder or in the lathe by means of a diamond pointed tool. It is not possible to get good results unless the face of the stone is clean, free from grooves, and in absolute alignment with the axis of the mount-

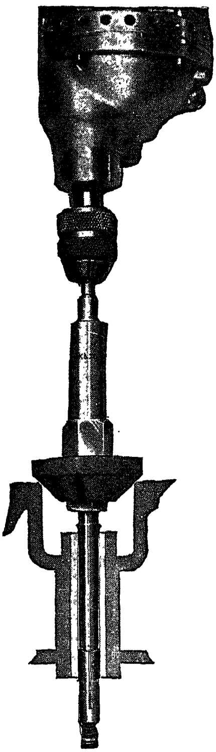


Fig. 25. Refacing Valve Seats in Cylinder Block or Cylinder Head (Black and Decker Practice)

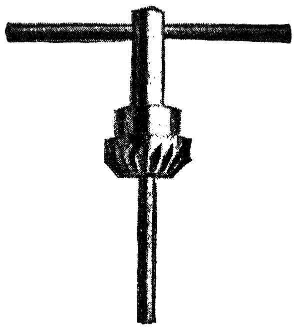


Fig. 26. Valve-Seat Refacing Tool

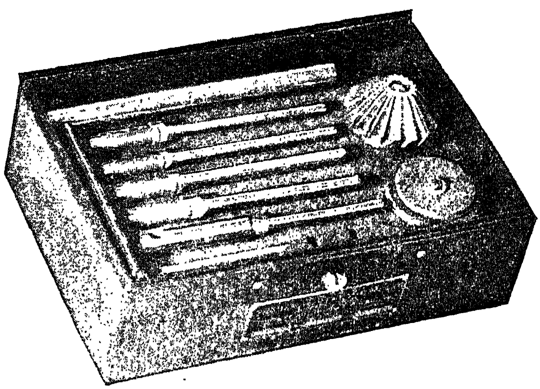


Fig. 27. Valve-Seat Refinishing Tool with Set of Arbors

ing shaft. A set of these stones and arbors may be purchased which will take care of a great variety of work, in fact, practically all work which may come into the average garage. Never grasp the arbors in the vise while tightening them or permit anyone to abuse them in any fashion, otherwise they will not be true and good work cannot be done by means of them.

Reseating Valves with Reamers. At one time the amount of service an automobile would give was not measured in such exceedingly large units as at present. For this reason a set of valves could be ground and reground a sufficient number of times to serve for the life of the ordinary engine. When engines were so built that their parts would stand up for service of hundreds of thousands of miles, it was found that the valve seat would wear away after repeated grinding and was only to be reconditioned by means of special tools. In order to accomplish this, the special seat refacing or reaming tools were designed. These are ordinarily spoken of as valve-seat reamers. They are made with an angle face corresponding to the usual valve face, most of them being 45 degrees. They may be purchased in either the roughing or finishing style. It is also possible to purchase reamers which will reduce the amount of metal surrounding the valve seat itself. These are the 70- or 75-degree cutters and the 15-degree cutters. The simplest form of these valve reamers is shown in Fig. 26. A set of arbors with a reamer is shown in Fig. 27. When using a reamer of this type, the first problem is breaking through the hard crust or scale which is left on the valve-seat face after thousands of miles of operation. Exert considerable pressure downward while driving the valve reseating tool in a forward direction. Do not back up on the tool and do not attempt to turn it without sufficient pressure to see that it bites through the crust immediately. Once through the crust, the reaming operation is comparatively easy. If the teeth are allowed to slide over the crust, they in turn may be damaged and the work made very difficult.

Fig. 28 illustrates the steps in refacing valve seats when it is desired to secure the best possible job with the new face not too wide. The width of this face is recommended as $\frac{1}{16}$ inch. Not all engineers will agree on this, some claiming that $\frac{1}{32}$ inch is the best width for the valve seat, others claiming that as much as $\frac{1}{8}$ inch will do no harm. The objection generally raised to the wide valve is the fact that carbon may accumulate under it and prevent the valve seating. The smaller the area, the more likely that any carbon striking it will be forced out and the original valve seat maintained.

The first step is to use the reamer shown at *A* in Fig. 28. This is a roughing reamer having serrations on the teeth. This first step

should proceed until clean metal shows at all points around the circumference of the valve seat. The next step is to inspect the work and then use the 15-degree reamer, as shown at *B*, cutting off a slight amount of metal. The next step is to use the 70- or 75-degree reamer, as shown at *C*, reaming out just a small amount of the valve port metal to clean it up. Make an inspection of the work to see whether the cross section of the valve seat would correspond to the cross section illustrated at *E*, which shows the valve head and valve

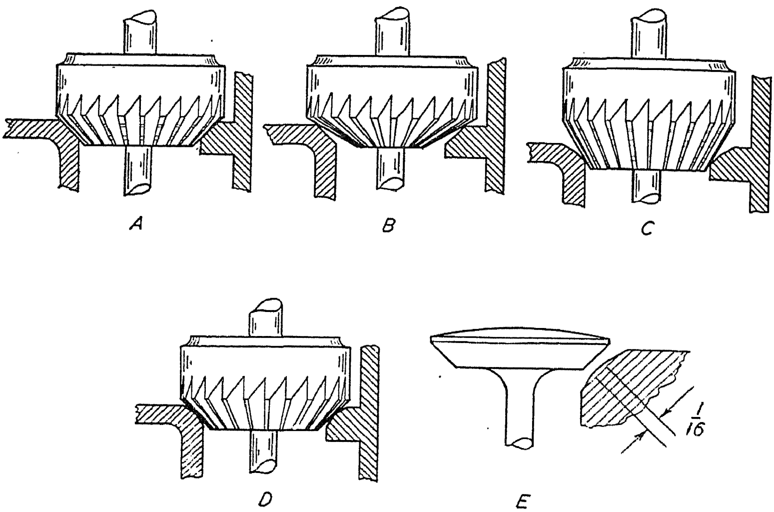


Fig. 28. Steps in Refacing Valve Seats

seat in enlarged section. The 45-degree section should be approximately $\frac{1}{16}$ inch, as indicated in this figure. If the work appears to be satisfactory, the final step in the valve reaming operation is to use the 45-degree finishing reamer, as shown at *D*, taking a very slight cut in order to clean up the work.

After refacing valve heads and reseating the valves in the cylinder block or cylinder head, it is very likely that it will be necessary to grind the valve in by hand. Only a very small amount of this work should be necessary if the machining operations have been performed properly. In order to make a test, use a very small amount of fine grinding compound to touch up the valve faces to the valve seats with a few turns. Then they are ready for testing.

Valve Guides. One of the first things to be done with a valve guide is to have it cleaned of carbon and gum accumulations. This may be done by means of kerosene or gasoline and a rag on the end of a steel rod. Perhaps the better method is to use a wire brush, such as that illustrated in Fig. 29. This is grasped in the chuck of the $\frac{1}{4}$-inch electric drill and forced through the valve guide while being rotated by means of the drill. This will ream out the accumulation of gum and carbon and will polish the inside of the valve guide.

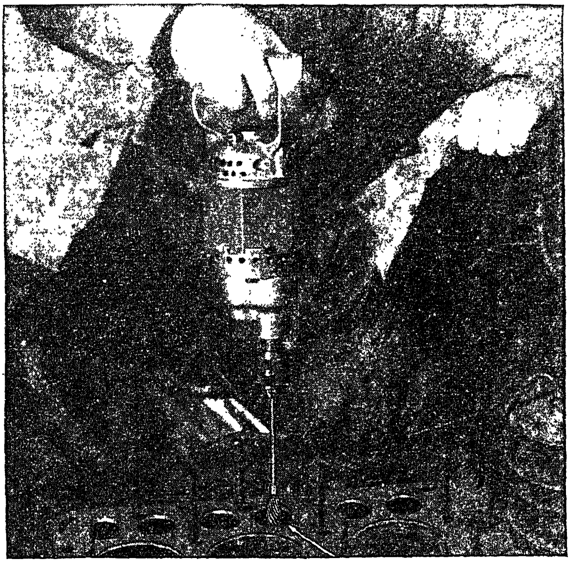


Fig. 29. Using Wire Brush for Cleaning Valve Guides of Carbon and Gummed Materials (Black and Decker Practice)

Installing New Valve Guides. It sometimes happens that valve guides will become so worn that it is necessary to replace them. This is not possible in all instances, as in some cases the valve guide is machined as part of the cylinder head or the cylinder block. An inspection will show whether the valve guide has been pressed into the block or head, which is usually the case. Valve guides which wear are usually worn in an oval or oblong fashion so that the valve may flutter or flop from side to side. This permits the valve head to hang on the valve seat and may be the cause of irregular operation of the engine.

When removing valve guides, the best practice is to make or purchase a puller. These pullers operate with a screw thread so that as the pressure is applied by turning the screw, the valve guide may be pulled from the cylinder block.

In installing these valve guides a similar method is used. This is illustrated in Fig. 30, where it will be noted that by turning the screw the valve guide is driven in from the bottom of the block. It

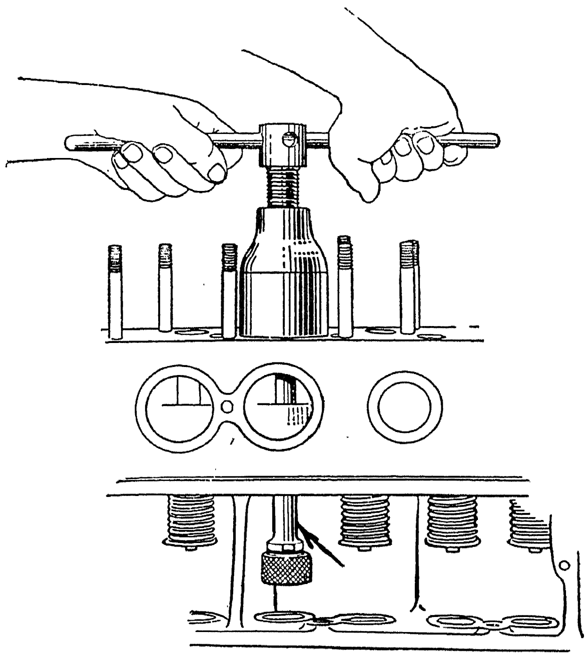


Fig. 30. Installing Valve Guides with a Puller
Courtesy of Studebaker Corporation

is not good practice to attempt to install these valve guides by means of a hammer and drift, although this is sometimes done. It is sometimes possible to use the arbor press in forcing them out. This is to be recommended if no puller is available. If no other method is available outside the use of the hammer and drift, the drift should be a bronze one and extreme care should be used to see that the valve guides align before driving them home.

Testing Valve Fit. After reconditioning valves by any method, it is desirable to make a test on valve fit to see if it is gas tight.

The use of the soft pencil marks, such as indicated in Fig. 31, is a very common practice with auto mechanics. After the valve has been reconditioned, it is removed from its position in the engine and a number of soft pencil marks are run across its face. The valve is then installed in the engine again and given a very slight turn forward and back. The amount of this turn should not exceed the distance between two pencil marks. Use a fair pressure when making

Fig. 31. Testing Fit of Reconditioned Valve with Lead Pencil Marks

this test during the turning. Remove the valve and check it to see whether the marks have all been erased at some one point in its length. If the seat is perfect, they will each show a slight erasure near the center of the face, as shown in the figure. If there are some which do not show this, it indicates that the valve is not seating at all points and should be reconditioned again and checked another time.

Some mechanics use bearing blue for making this test. A very slight amount of bearing blue is placed on the seat of the valve and rubbed in with the finger. The valve is then dropped into position and given a very slight turn. If the proper fit has been secured, the

blue will be in evidence on the face of the valve. The blue may be applied to the valve or valve seat, but not to both.

Installing Valves and Valve Springs. The next operation after reconditioning valves is to have them properly installed. The pressure required to set up a valve spring is very considerable—running up to 100 pounds and over. This means that with the close space in

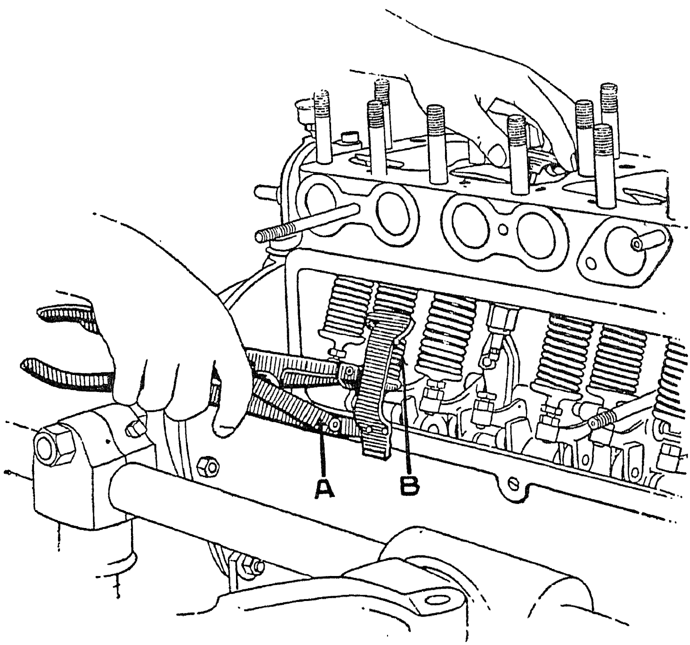


Fig. 32. Installing Valve and Valve Spring (Studebaker Practice)

which the mechanic must work, he oftentimes encounters a very stubborn job. This work may be expedited if the mechanic will make use of those valve-lifting devices which have in connection with them a spring compression device. This work may be done at the bench. The spring is compressed and then is held, as indicated at *B* in Fig. 32. This makes the installation of it much easier. After the spring has been installed, the retaining device is removed. Not all valve lifters are provided with such a device. The mechanic may make them in his own shop out of strap iron if he so desires. Com-

press one of the springs and note the height of the compressed spring, after which U-shaped irons may be fitted up and slipped onto the side of the spring to hold it compressed while installing it. A spring

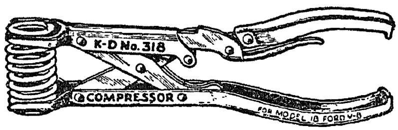


Fig. 33. Valve Spring Compressor

compressor is illustrated in Fig. 33. After the spring is in position, make very certain that the valve-spring retaining or locking device is properly set before releasing the spring compression on it. This is

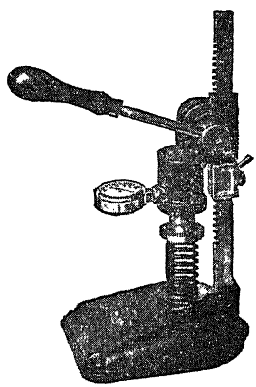


Fig. 34. Testing Valve Spring with Stevens Valve-Spring Tester
Courtesy of Stevens-Walden-Worcester Company

very important, as it not infrequently happens that improperly installed locking devices will give service for a short distance and then drop out, causing the engine to fail. Not infrequently serious consequences follow such failure. The valve may stick or be driven into the cylinder head or even through it or through a piston. Parts falling into the crankcase may get into the gears and thus cause serious damage. They may strike the connecting rods as they turn and be driven through the crankcase or oil pan.

It is a good plan to put the engine into operation for a short

time, after which a final check is made to see that all of these valve retaining keys or locks are remaining in position.

Testing Valve Springs. Owing to the fact that considerable heat is present at the position in which valve springs operate, it is very frequently necessary to check them as a source of possible trouble. When the engine is down for rebuilding, it is a good plan to check all of the springs against the manufacturers' specifications. As a rule, valve springs should not show less than 45 pounds pressure

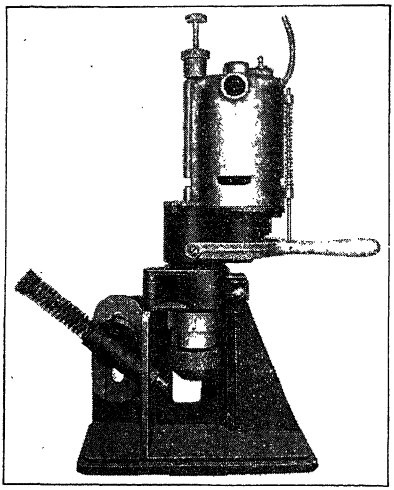


Fig. 35. Hall Eccentric Valve Seat Grinder
Courtesy of The Hall Manufacturing Company

when they are compressed to the normal length of the spring, with the valve closed. They should show approximately twice this amount when the valve is open or when they have been compressed to a corresponding length. It is a good plan to check all of them and if some are found to be weak, these should be discarded in favor of new ones, as it is very likely the temper of the valve spring has been destroyed. All valve springs are subject to fatigue which means that after thousands of miles of use they have lost some of their original tension. It may be that the valve springs of a job should be replaced in order to restore the engine to its former snap and power.

Valve Spring Tester. The Stevens valve-spring tension tester is shown in Fig. 34. It is a simple device which registers the number of pounds pressure demanded to set the valve spring to the predetermined size as shown by the gauge. Most car manufacturers furnish specifications relative to the pressure required to set the springs on their product to the point which represents open valve conditions. This dimension is stated in inches.

Reconditioning the Hardened Valve Seat. Valve inserts are sometimes made from hardened metal difficult of machining except by grinding. An eccentric grinder operating at a spindle speed of 9000 revolutions per minute may be used for this work. This grinder, illustrated in Fig. 35, has a high-speed shaft revolving in an eccentric shaft which turns thirty times per minute. The bevel of the grinding stone is that of the finished seat. Only point contact is made by the stone with the result that the action is similar to that of cylinder grinding. The device mounts in the valve stem guide. The stone is first set close to the seat and then the feed of the spindle is used to adjust the stone as it is fed to the work. The handle on the machine is used to balance the torque and permit of fitting it to all types of motors.

Servicing Valve Seats. Where the valve seat is not removable or where it is actually cut into cylinder block metal, care should be taken, when using valve seating equipment, not to cut away any more metal from the seat than is actually necessary.

Cutting away the seat will reduce the valve spring pressure. This will cause valve noise, the valve to bounce on its seat, valve sticking, and less cooling of the seat. The valve head will have a higher temperature, and sharp edges may be formed at the outside edge of the valve, which might result in these sharp edges becoming hot enough to cause pre-ignition.

PIERCE ARROW AUTOMATIC HYDRAULIC VALVE LIFTERS

These valve lifters, Fig. 36, utilize the oil pressure for maintaining a non-clearance and quiet operation of the valve lifter. They are mounted in cast iron guides, in groups of four. This guide group is bolted to the block and covers a pocket in the block, which is supplied with oil, under pump pressure, and which, in turn, dis-

tributes the oil to each of the lifters. From this pocket, passages are drilled, which supply the operating pressure through the guide to each individual lifter. The valve lifter and mushroom are machined from a single piece of tough alloy cast steel. These are very

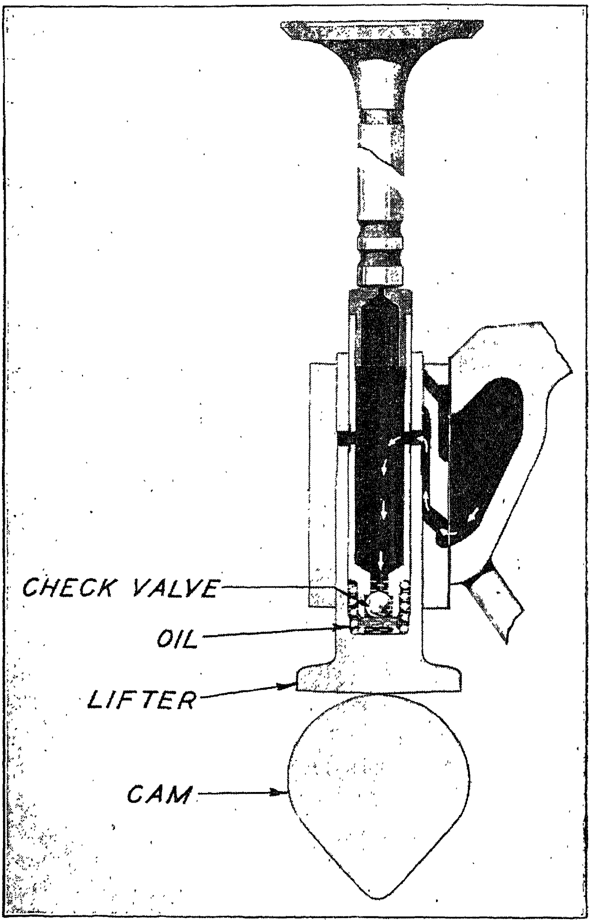


Fig. 36. Pierce Arrow Automatic Hydraulic Valve Lifter

accurately ground to fit the guide with the proper clearance, as are all of the component parts of the lifters, such as the plunger.

Oil is introduced through the guide and through holes in the lifter body, into the center portion of the lifter plunger. A light

spring at the bottom of the plunger holds the lifter at a no-clearance position when no lifting strain is on the plunger. This leaves a space beneath the plunger, which is immediately filled by oil under pressure from the oil pocket through the lifter and guide. As this

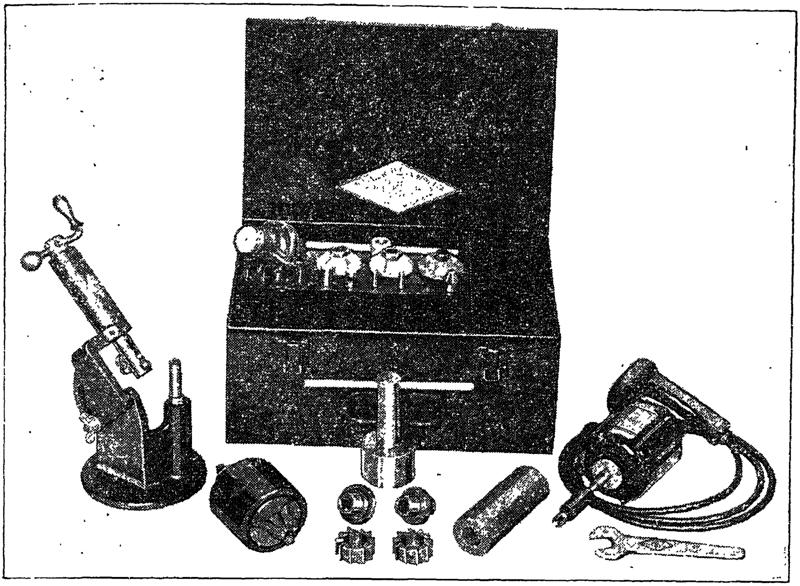


Fig. 37. Valve Grinding Equipment
Courtesy of Miller Tool Manufacturing Company, Detroit, Michigan

pocket is filled, a ball-check valve in the bottom of the valve lifter plunger prevents the escape of the oil from this space beneath the plunger to the oil line. Any escape of oil from this space through leakage is immediately replaced by oil, under pressure, the moment the lifting strain is released from the lifter. As the oil in this space is not compressible under the amount of pressure exerted on the plunger, it will readily be seen that this cushion of oil, in effect, solidifies the entire lifter into one piece, with the plunger oil cushioned.

At the upper or valve end of the lifter is a hardened insert cap. The center of this cap contains a $\frac{1}{32}$-inch hole, which is covered by the valve stem, and its sole purpose is to allow the escape of air from the plunger. Any air which should accidentally be introduced

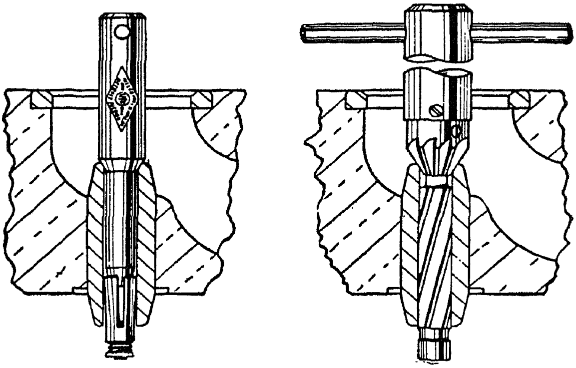


Fig. 38. Cleaning Valve Guide and Chamfering the Guide
Courtesy of Miller Tool Manufacturing Company, Detroit, Michigan

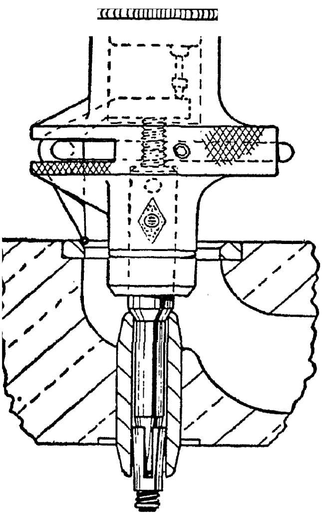


Fig. 39. Testing Valve Seat for Run-out or Eccentricity
Courtesy of Miller Tool Manufacturing Company, Detroit, Michigan

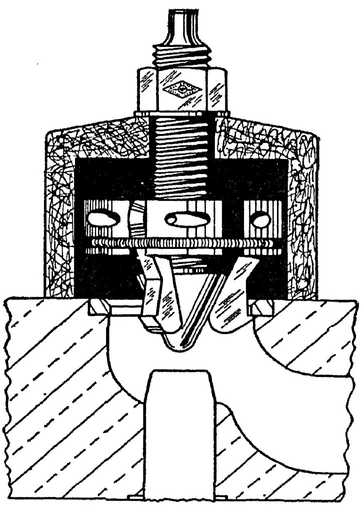


Fig. 40. Hardened Valve-Seat Insert Puller
Courtesy of Miller Tool Manufacturing Company, Detroit, Michigan

to the chamber beneath the plunger would be compressible and would, therefore, give clearance when pressure was applied and until the air was replaced by a solid body of oil.

Between the plunger and the bottom of the lifter proper, there must be at least $\frac{1}{16}$-inch mechanical clearance when a lifter is installed dry. It can readily be seen that if this clearance is not initially made, the effect of the hydraulic action will be lost in the mechanical maintenance of the overall length of the lifter.

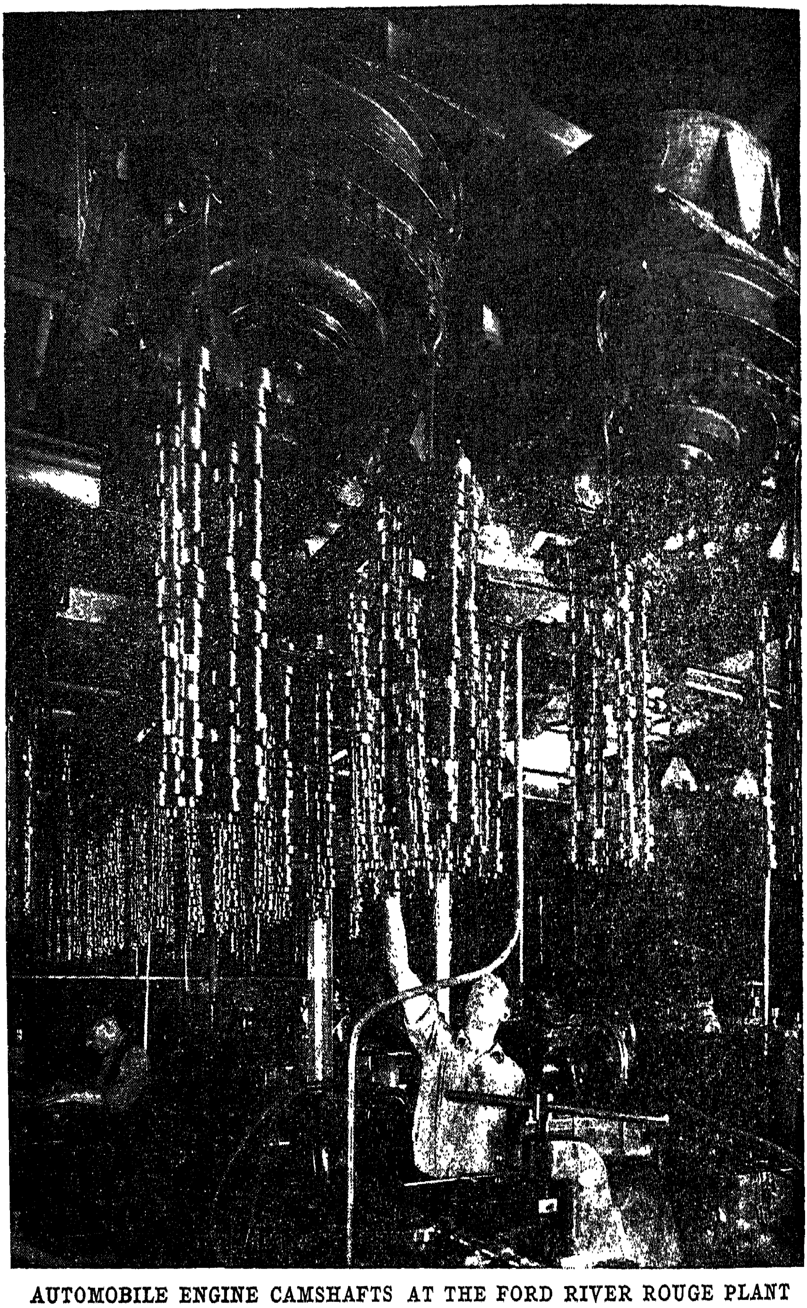
DODGE VALVE RECONDITIONING

The exhaust valve seats in Dodge engine exhaust ports are of the insert type, and are constructed of very hard material. For that reason they cannot be re-cut but must be re-ground or replaced, and special tools, as shown in Fig. 37, are required for that purpose. When using the reconditioning equipment the following points should be watched. Be sure the valve guides are clean and the upper end of the valve guide must be chamfered to provide a pilot for the grinding tool. Fig. 38 shows these operations. The valve guide pilot must fit snugly into place and be securely tight so there can be no eccentricity in the rotation of the tool. Any such eccentricity would of course throw the seat out of line with the guide. The grinding sleeve must also be closely checked for concentricity and if found not to revolve freely it should be dressed until it runs true. To maintain the proper grinding speed the stone should be operated dry.

When the seat is finished it should be checked with an indicator, and the run-out or eccentricity of the seat should not exceed .0005 inch. Fig. 39 illustrates this test.

Best results are obtained where the seat is given a mirror finish.

If it is necessary to remove and replace hardened valve-seat inserts, a special tool must be used as shown in Fig. 40. The tool has three jaws or claws which are forced beneath the insert when the center screw is tightened. When the jaws have a good grip on the under side of the insert, the main or central nut on the puller is tightened to pull out the insert.



AUTOMOBILE ENGINE CAMSHAFTS AT THE FORD RIVER ROUGE PLANT

Courtesy of Ford Motor Company

VALVE-OPERATING MECHANISMS

CAMSHAFTS, TIMING GEARS, AND ENGINE TIMING

Camshafts. For the actuation of the valve mechanism of any four-cycle engine, it is necessary to have a shaft, Fig. 1, turning at one-half the speed of the crankshaft through a two-to-one gear ratio.

In laying out or designing a set of cams for a gasoline engine, such as is used on an automobile, it is first necessary to decide

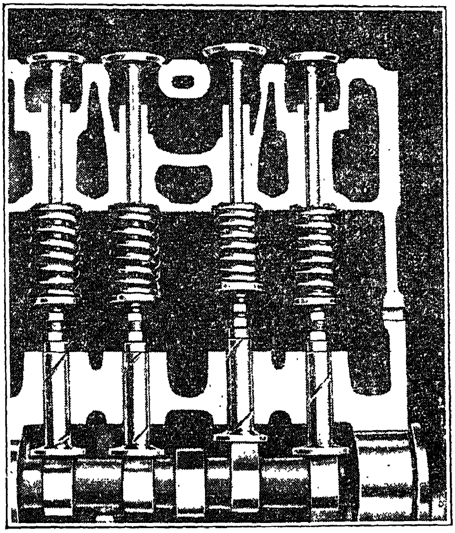


Fig. 1. 1937 Oldsmobile Valve Action
Courtesy of Olds Motor Works

upon the exact cycle upon which to operate the engine. By this is meant the exact length of time, as referred to the stroke, in which the valve action will take place. Upon this subject designers all over the world differ, and no wonder, as this cycle can but be judged by results, for it is impossible to watch it as it operates. Deductions differ, therefore, as to what happens and consequently, as to the effect of various angles of beginning and ending the valve actions.

A camshaft changes rotary motion to reciprocating motion.

Fig. 1 shows four cams with four cam followers. Valve No. 2 is open having been forced up by the cam follower or lifter which rests on the nose of the cam.

Cam Function. Granting the necessity for proper means to regulate the inflow and outgo of the charge and consequent products

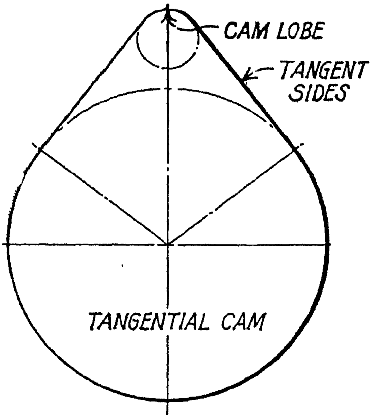


Fig. 2. Tangential Cam

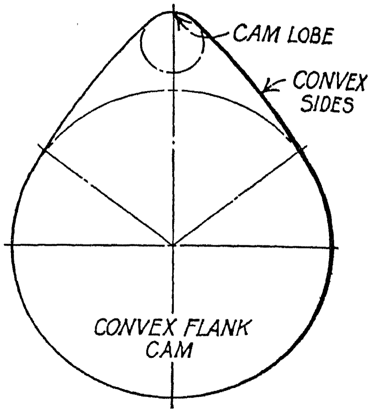


Fig. 3. Convex-Flank Cam

of combustion, as exemplified by the valves, the next most important part is the one which controls the movement of the valve and is, therefore, essential to the success of the latter. This is what is known as a cam and in the usual case amounts to an extension of, or projection from, the so-called camshaft. Inasmuch as the valve opens once upon every other turn of the crankshaft, this camshaft is gear-driven from the crankshaft so as to rotate at half the speed of the latter. This is very simply effected by having the cam gear twice as large as the crankshaft gear. As the same valve is never used for both the inlet and the exhaust, so the cams are seldom made to do more than the one thing, namely, operate one set of the valves. From this has grown the custom of referring to them according to the function of the valve which they operate—inlet cam or exhaust cam.

The speed at which the valve opens and closes is governed by the shape of the cam outline as well as by the size and shape of the

cam follower. To get the largest amount of gas into the cylinder, it is often necessary to have the valve open and close quickly and, at the same time, have it remain open as long as possible. On the other hand, the valve gear must operate as quietly as possible, and therefore the drop and lift must be gradual. There are two types of cams and cam followers, the tangential cam, Fig. 2, and the

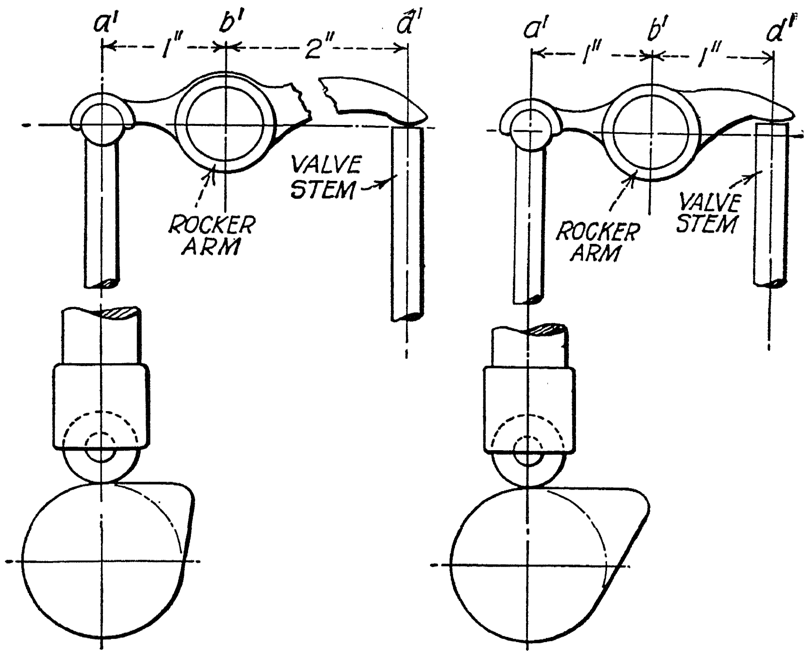


Fig. 4. Relation of Rocker Arm to Cam Travel

convex-flanked cam, Fig. 3, both of which can be used with a mushroom-type follower.

One way to reduce the spring tension is to increase the travel of the cam by the use of a longer valve-rocker arm, Fig. 4. The distance between *a′* and *b′* in ratio to *b′* and *d′*, Fig. 4, doubles the travel of the follower and, therefore, it only has to travel half as far. This reduces the speed at which the cam must travel as well as the amount of acceleration or lift of the cam.

The things to be aimed at in the design of cams and valve mechanisms are greater volume and the least possible strain on

all valve parts. Of course, silent operation is a desirable feature, but the best possible performance of the engine should come first. Therefore the rapid opening and closing of the valves with lightness of parts is to be commended. The use of more than two valves per cylinder tends toward the use of lighter valve parts and weaker valve springs and, therefore, less reciprocating weight and wear on cams and camshaft and shaft bearings.

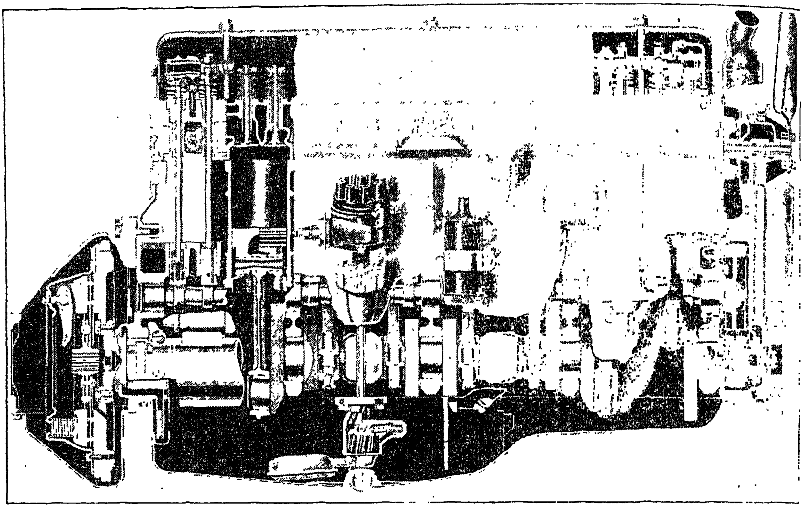


Fig. 5. Buick Valve Action
Courtesy of Buick Motor Company

Fig. 5 illustrates valve action of Buick valve-in-head engine.

Relation of Valve Opening to Crankshaft Travel. The valve opening bears a definite relation to the crankshaft and piston travel, since for good operation the valves must remain open as long as possible. It is often necessary to vary the length of time that the valve is open or to make some change in the valve timing, and to find the length of time that the valve is open before making any change. The crankshaft makes two revolutions to complete the cycle in a four-stroke cycle engine, and the intake valve is open a certain number of degrees the first revolution and the exhaust valve is open a certain number of degrees the second revolution. Therefore, each valve is open for a certain number of degrees in 360 degrees

of crankshaft travel. Fig. 6 shows a valve timing in which the intake valve opens at 10 degrees after top dead center and closes at 45 degrees after bottom dead center. It will be noticed that the valve is open one-half a revolution less 10 degrees, or 170, plus 45 degrees, which is the amount that the valve is open after the bottom dead center point is past, which makes a total of 215 degrees of crankshaft travel.

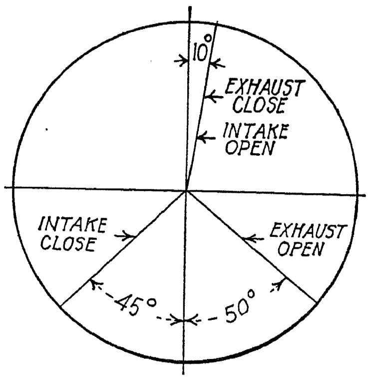


Fig. 6. Valve-Timing Diagram

The rule for the intake valve is as follows: *Deduct the amount that the intake is closed after top dead center from 180 and add to that result the amount that the valve remains open after bottom dead center.*

The rule for the exhaust valve is as follows: *Add to 180 the number of degrees that the valve is open before bottom dead center plus the amount the valve is open after top dead center.*

For instance, in Fig. 6, the exhaust is open 50 degrees before bottom dead center and remains open 10 degrees after top dead center. Therefore, the valve is open 180 plus 50 plus 10, or a total of 240 degrees of crankshaft travel. If the timing of the valve is made earlier in opening, the closing will also be earlier, or vice versa, and the piston will not be as far down on its stroke or will be farther down, according to whether the timing is advanced or made later. This has a distinct bearing on the amount of gas drawn into the cylinder. The cam is so arranged that there will be a slight vacuum in the cylinder when the intake valve opens, because this causes a

quicker intake of gases and the quick valve opening aids this condition. The opening should not be delayed too much or the suction will be greatly decreased and the power output lessened. A change in timing can be made with little trouble if the above rules are remembered.

Timing Gears. Practically all of the earlier engines used the

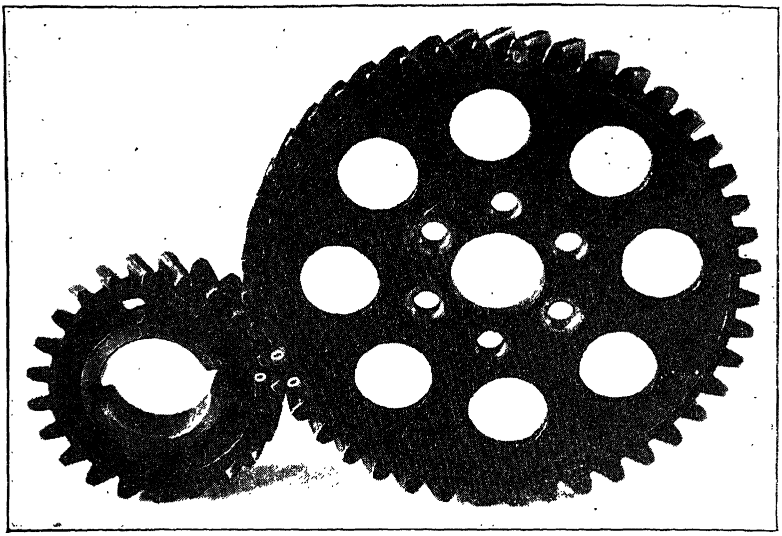


Fig. 7. Timing Gears (Crankshaft and Camshaft), Showing Timing Marks

spur-gear drive in order to keep the crankshaft and the camshaft in time. The great trouble with the spur gear was its noise. In an effort to get away from this disturbing noise, the spiral gear or the helical gear was introduced. Where gears are used today, they are invariably of the helical type. Owing to the fact that more than one tooth is engaged at the same time, the operation of the gears is much quieter.

In a further effort to quiet the timing gears, other special gears have been introduced. These are made from special fabrics, being pressed together under hydraulic presses and machined in exactly the same fashion that a metal gear would be machined. Bronze gears have been tried for this service. In certain installations, aluminum idler gears have been used. There are many combina-

tions which have proven very popular among the automobile owners and among the automobile service men. These are advertised in all of the trade journals and their special qualifications featured. The service man will doubtless want to connect up with a jobber who can furnish these special gears to him with the regular discounts. The public demands silent drive for the front end of the engine and the ability to render service in this respect is necessary.

Fig. 7 shows the most usual practice with reference to the timing gears. It will be noted that these timing gears are marked, in this case with the letter "o" on the crankshaft gear and "oo" on the camshaft gear. It is also noted that the crankshaft gear has certain keyways cut in it and the camshaft is mounted by means of studs. Not infrequently it is impossible to install a camshaft gear in more than one position on the camshaft; likewise with the crankshaft gear. Under these circumstances then, all that is really necessary in timing up the engine is to have the marks meet properly, as shown in Fig. 7. On the other hand, an exact knowledge of engine timing will enable a workman to properly time an engine irrespective of whether there are any marks on the timing gears or not, which is ofttimes the case when purchasing a new set of timing gears from the jobber. No service man is worthy of the name of automobile mechanic who is so deficient in knowledge of automobile engine design that he is unable to secure the proper engine time when installing new timing gears or a timing chain for front-end drive.

Fig. 8 shows the moving parts of the Ford V-8 engine. The crankshaft, camshaft, and the timing gears are in relative position although the gears are not meshed. The relation of the cams, valve lifters, valve springs, and valves is also indicated by the drawing.

Timing Chain and Timing-Chain Sprockets. The fact that the timing gears after they were worn a bit were inclined to give off a disagreeable noise led the engineers to experiment with what is known as silent-chain drive for the front end of the engine. This is the form of chain which is somewhat on the order of a linked belt and is so known and marketed by one manufacturer of this type of chain. The use it serves is exactly the same as the timing gears, that is, it maintains the ratio of 1-2 between the crankshaft and the camshaft. It is claimed by many engineers that it is superior to the best possible design of gears for this work. However, not all

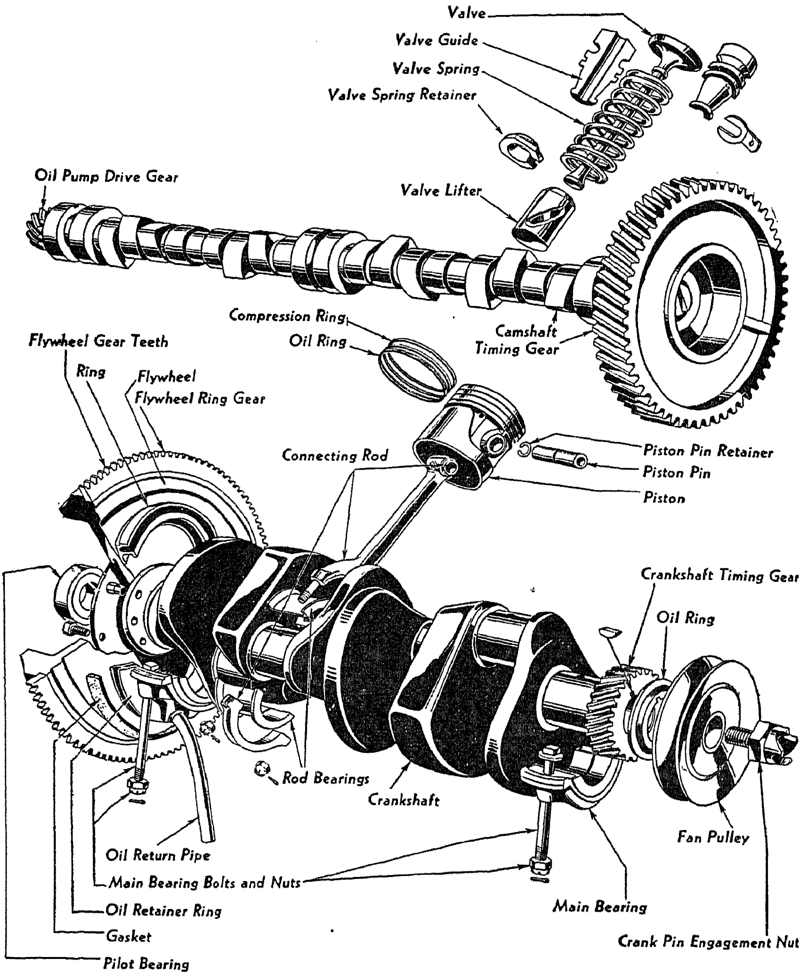


Fig. 8. Ford V-8 Engine Parts
Courtesy Ford Motor Company

engineers have accepted these claims as being absolutely proven. As a matter of fact, there are a number of high-grade engineers who still hold to the gear drive for the front end. Fig. 9 shows

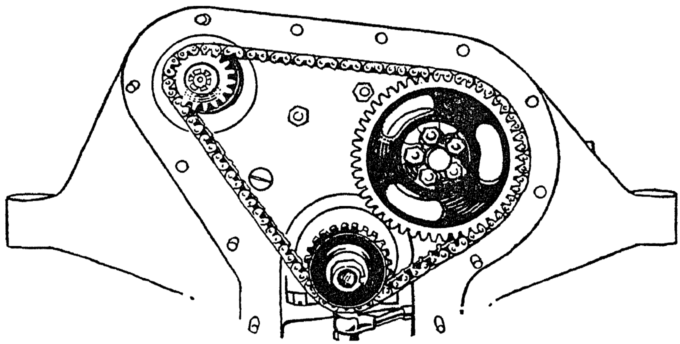


Fig. 9. Silent-Chain Drive of Conventional Form

a most usual type of front-end drive where the chain is used. With this arrangement it is easier to design the position of the camshaft with reference to the crankshaft and the position of the accessory

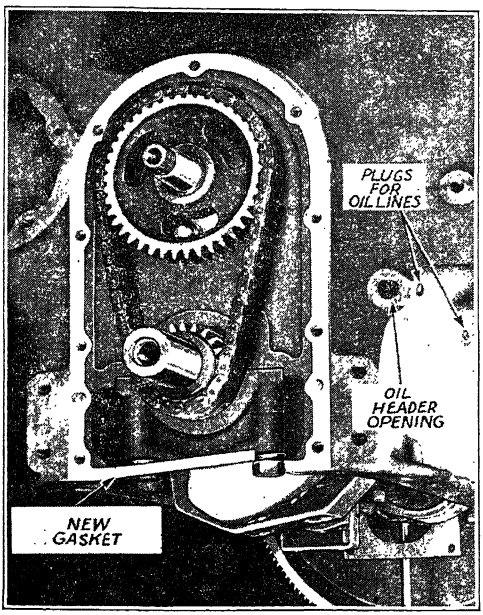


Fig. 10. Front View of Eight-Cylinder V-type Motor Timing Chain
Courtesy of Cadillac Motor Car Company

shaft, since a slight variation in these positions may easily be taken up by chain adjustment.

Chain adjustments are of several definite types. Two-sprocket chain drives, as for instance the one shown in Fig. 10, are not adjustable, except by removing a hunting link as explained later.

The manual adjustment of a chain is ordinarily effected by means of having the accessory shaft, which may be the generator itself, manually adjustable. As the chain wears, the adjustment

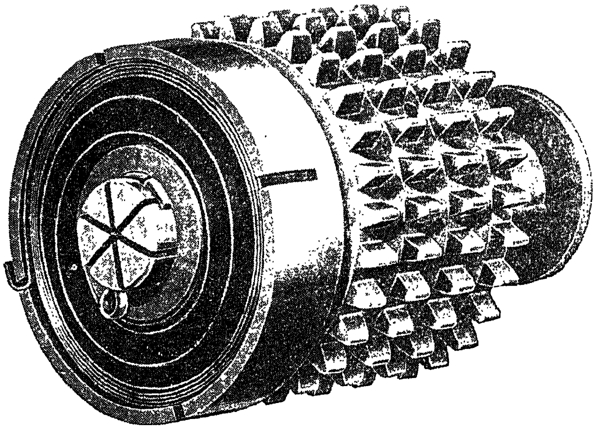


Fig. 11. Automatic Chain Adjuster
Courtesy of Link Belt Company

is effected from the outside of the timing gear case by releasing several nuts and then throwing the generator to the side, after which the generator is secured by tightening the nuts.

An automatic adjusting device, such as is shown in Fig. 11, is used by a number of motor-car builders. This device is actuated by spring tension so that as chain wear occurs, the spring automatically takes it up, keeping a certain definite tension on the chain at all times. The application of the automatic chain adjuster is shown in Fig. 12, where it is installed between the pump or accessory gear and the crankshaft gear. The pull is then from the crankshaft gear toward the camshaft gear and from the camshaft gear toward the pump gear. The idler does not transmit any pull; it simply takes up the slack between the pump gear, which is the last driven gear, and the crankshaft gear, which is the driving gear.

Valve Timing. The increase of speed without material altera-

tion in the engine is what every repair man aims to get when he goes over the timing of the engine. Valve timing has been called an art, but it is not; it is only the application of common sense and the known valve diagram to any particular engine in an attempt to get the best all-round results. These, as might be expected, are a compromise, and that repair man does the best timing who realizes this and, instead of attempting the impossible, simply produces the most desirable all-round compromise. Although the manufacturers

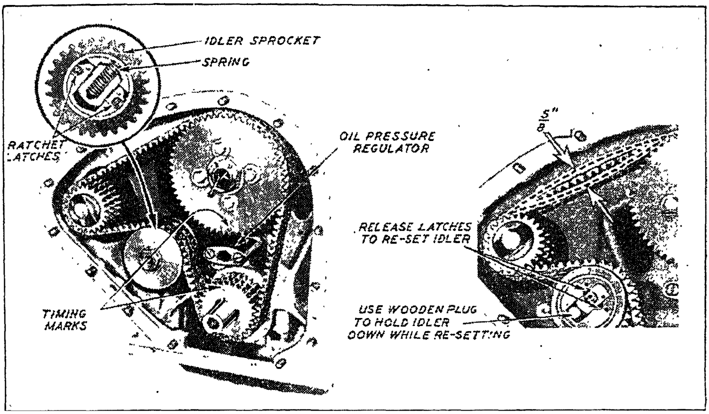


Fig. 12. Cadillac Series 36-80 and 85 Timing Chain Construction (Left) and Directions for Re-setting Chain Adjuster
Slack in chain is taken up by idler sprocket moving toward camshaft.
Courtesy Cadillac Motor Car Company

usually have a valve timing which is suitable for their particular product, the following is a general rule for timing engines.

Rotate the crankshaft until the piston in number one cylinder comes to the top of its stroke. With the camshaft gear out of mesh, move the shaft in its proper direction of rotation until the exhaust valve has just closed, and then mesh the gears.

If the work has been done correctly, the intake valve should start to open as soon as the piston starts to move down on the suction stroke. The exact point of closing can be found by inserting a thin piece of paper between the tappet and the valve stem and lightly pulling on it. When the valve closes, the paper will be free and can be pulled out. The timing gears are coarse enough so that an error will show when the work is checked. To check the timing, insert a piece of paper between the tappet and the valve stem.

Rotate the crankshaft, lightly pull on the paper, and when the paper is free, the piston should be at the top of the stroke.

In finding the top dead center, insert a stiff wire in the cylinder and mark the point at which the piston ceases to rise. Move the piston and mark the point where it starts to move down. The midway between the two marks is the top dead center.

Where the actual valve timing is not known, the average setting—which can be used for the trial setting—is as follows: intake valve opens between top dead center and 10 degrees past top dead center, and closes 45 to 50 degrees after bottom dead

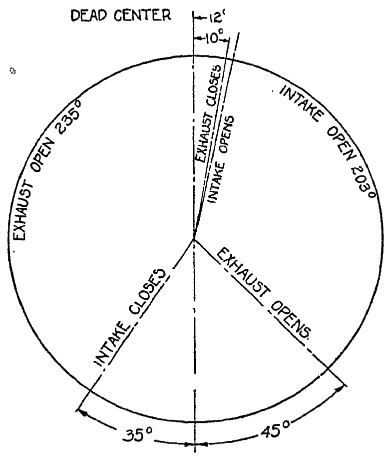


Fig. 13. Valve-Timing Diagram for Four-Cylinder Engine

center; exhaust valves open from 45 to 40 degrees before bottom dead center and close 10 to 18 degrees after top dead center. The exhaust valve is opened at this point because all of the useful expansion of the gas is gone. This insures a clean exhaust and prevents over-heating and back pressure on the piston.

Flywheel Markings. Nearly all engines now have the timing marked upon the rim or face of the flywheel, so that it is unnecessary to bother with the crankshaft and pistons. This has been found by experience to be the best and handiest way, for the flywheel is generally accessible without removing many other parts. The same is true with the valves. This is not the case with pistons and

crankshaft; moreover, with these it is difficult to determine the exact upper and lower dead centers, and still more difficult to work to angles.

To use these settings marked on the flywheel, a stationary pointer on the upper surface of the crankcase hangs over the flywheel surface as closely as possible and indicates the reading. The flywheel is turned by hand or by means of the crank at the front of the engine until a mark or the desired mark is brought up to the pointer. Thus the cylinders are marked from front to back always, that nearest the radiator being 1, the next 2, then 3, and the last, in the case of a four-cylinder engine, 4. In a six-cylinder engine the method is the same with the addition of two cylinders, the one nearest the dash being 6. The flywheel sometimes has the positions marked on its surface, as well as the valve operations. Fig. 13 shows the valve-timing diagram of a four-cylinder engine. Notice in this that none of the valve operations begin or end on a dead center point so that even if the centers are marked on the flywheel, as they are in this case, this is of little benefit except as will be pointed out. The marks on the flywheel and what they mean are as follows:

1-4 UDC	Means that pistons in cylinders 1 and 4 are in their uppermost position, or at upper dead center.
2-3 UDC	Means that pistons in cylinders 2 and 3 are in their uppermost position, or at upper dead center.
1-4 I-O	Means that inlet valve cylinder 1 or 4 (not both) opens.
1-4 I-C	Means inlet valve of cylinder 1 or 4 closes.
1-4 E-O	Means exhaust valve of cylinder 1 or 4 opens.
1-4 E-C	Means exhaust valve of cylinder 1 or 4 closes.
2-3 I-O	Means inlet of cylinder 2 or 3 opens.
2-3 I-C	Means inlet of cylinder 2 or 3 closes.
2-3 E-O	Means exhaust of cylinder 2 or 3 opens.
2-3 E-C	Means exhaust of cylinder 2 or 3 closes.

Remember that on a four-cylinder crankshaft the first and fourth crankpins are up (or down) together, while the second and third are down (or up) together. The firing order of the cylinders is 1- 3- 4- 2. To apply this knowledge, open the pet cocks so the

engine will turn over easily; selecting cylinder 1 to start with, turn the flywheel until the mark 1-4 UDC comes to the pointer at the top. Now continue turning to the left (at the rear end) about an inch more when the mark 1-4 I-O will be seen. Bring this slowly up to the pointer, when the inlet valve should just begin to move. This can be noted by feeling the stem, or by placing a wire upon the top of the valve and noting when it begins to be pushed upward by the valve movement. If this should happen in cylinder 4 instead of 1, turn the flywheel one complete revolution, bringing the same point to the top. If this is entirely correct, the flywheel can be turned in the same direction about 5 or 6 inches more than half a turn, when the mark 1-4 I-C will appear. Turn slowly until it reaches the pointer, when the valve in cylinder 1 should be completely closed. This can be determined again by feeling of the valve stem which should come down to its lowest position, or by the wire on the top of the valve. At this point the valve-tappet clearance comes in. When the valve tappet has reached its lowest point, and the valve has been allowed to seat, the tappet should go down slightly farther than the valve, leaving a very small space between the two. This is the clearance and it varies in normal engines from .002 inch to .012 inch. Use the thickness or feeler gauge to check the tappet clearance.

Valve-Stem Clearance. This clearance is necessary to compensate for the expansion of the valve stem when it becomes highly heated during the operation of the engine; the tappet or push rod does not become heated, consequently it does not expand. Practically all engines are made with an adjustment here in the form of a screw with a hexagon head which is hardened where it strikes the valve stem. If the clearance is less than the required amount or greater so that the engine is very noisy, the lock nut is loosened, and the screw gradually turned upward until it just begins to grip the blade of the thickness gauge. This should be done very carefully, for if the clearance is made too small, the valve will not seat fully when the engine is hot and the valve has expanded; on the other hand, if the clearance is made too large, the push rod will come up against the valve end each time with a bang, and eight of these repeated a thousand times a minute make a great deal of disagreeable and useless noise. In the modern engine, the cam-

are made an integral part of the camshaft. If the driving gear for the camshaft is in its right place and the camshaft bearings are all in good shape, this push-rod adjustment is the only valve adjustment possible. If the timing is not correct, that is, if none of the valve operations correspond with the marks on the flywheel and the maker's instructions, then the cam gear has been misplaced or the chain has stretched or jumped teeth.

It is not possible to set a definite amount for valve clearance in engines where the best possible performance is required, as racing and aeroplane engines. An equal amount of mixture must be obtained in all cylinders, therefore, all valves must be open at the same piston position. If this can be obtained by giving one valve more or less clearance than another, it should be done. Each valve should be tested individually, the position found, and the clearance given. The opening and closing positions of the valves are equally important. There is a difference in the amount of wear or in the shape of cams on the same shaft, and this should be taken into account when setting valve clearances on the engines mentioned.

The best position for setting the valve clearance is with the piston at the top of the compression stroke. Watch the intake valve when it opens and closes, and bring the piston to the top of that stroke. In this position the push rod or tappet is resting on the dead side or heel of the cam.

Exhaust-Valve Setting. The same procedure is followed through for the exhaust valve of the same cylinder, continuing past the 1-4 UDC mark to the mark 1-4 E-O. At this point the exhaust valve of cylinder 1 should just begin to open. Then continue around to the 1-4 E-C point where the exhaust valve of cylinder 1 is just completing its downward or closing movement. If there should be any need for adjustment here, this should be made before proceeding to the other cylinders. It should be stated that many makers give the exhaust-valve stems slightly greater clearance than the inlets, on the assumption that they work with hotter gases, are subjected to more heat, and should therefore expand more.

Relation of Settings in Each Cylinder. Having checked up and adjusted both valves for cylinder 1, follow through the same process for cylinder 4, then for cylinder 2, and then for cylinder 3. The diagram, Fig. 13, shows but the cycle in each cylinder, and the

description simply listed the markings to be found on the flywheel, so Fig. 14 is given to show the relation of these marks to one another. This diagram refers to a six-cylinder engine, and the timing is indicated on the face, but the repair man will understand that this is done simply for convenience, and that these marks are actually found on the rim. So, too, the lines drawn down to the center are simply shown for convenience in indicating the angles and do not appear on the flywheel. In this a different timing will be noted, in that the inlet opens later and closes earlier, while the exhaust opens earlier and closes earlier.

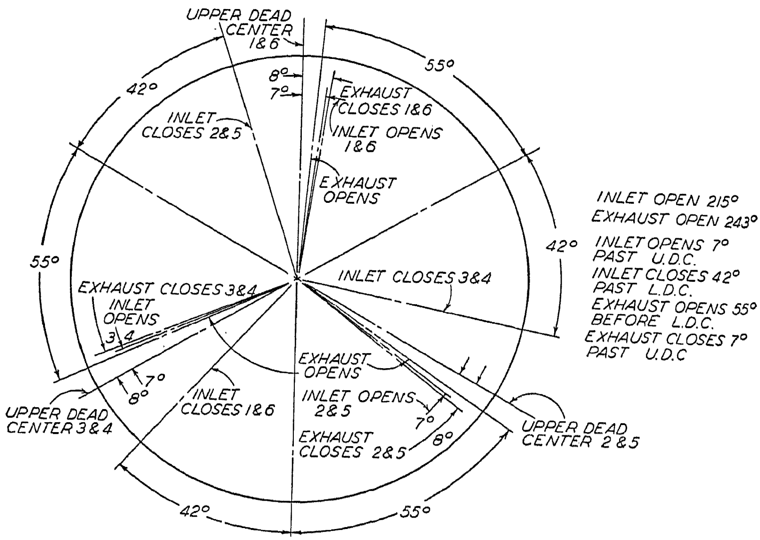


Fig. 14. Valve-Timing Diagram for Six-Cylinder Engine, Showing All Cylinders

There is now and always has been a wide divergence among designers on the subject of valve timing, so that the repair man must look for a different setting with each different make and often for a different setting with each different model of the same make. All that can be used for all cars is the general method, which is applicable whether the valves are all on one side (L-head cylinders), half on each side (T-head cylinders), all in the head or half on one side and the other half in the head, in short, regardless of the valve position. Similarly with regard to numbers, the method holds good

regardless of the number of valves per cylinder. Moreover, it applies regardless of the number and arrangement of the cylinders, as it is just as good for eights and twelves as for the engine described. On V-type engines there is a close relation between the opposing cylinders, right-hand No. 1 and left-hand No. 1, and this must be taken into account. In some engines, Fig. 8, there is a cam for each valve, in which case no trouble would ensue; but in others there are but eight cams for the sixteen valves of an eight-cylinder engine. This type of shaft will influence the timing diagram; and in setting, the repair man will have to concern himself with the same cam for two different valves—one in a cylinder of the right-hand group and one in a cylinder of the left-hand group.

How to Divide Flywheel Circumference for Valve Timing. In most engines the top dead center is marked, but the position of valve operation is not always shown on the flywheel rim. Valve operations take place so many degrees before or after top or bottom dead center. This means that a line which indicates the top dead center must be so many degrees past or before the center when a certain valve operation takes place. It is not always convenient to make a protractor for measuring the distance in degrees, but the distance can be laid out in inches on the circumference or surface of the flywheel. A circle consists of 360 degrees—so a degree will equal a certain distance in inches or parts of an inch on the circumference of the flywheel. The amount depends on the size of the flywheel. To find the number of inches per degree of flywheel circumference, multiply the diameter by the number of degrees, and divide by 114. The formula can be written thus:

$\frac{\text{diameter} \times \text{degrees}}{114} = \text{inches per degree}$. The diameter is the diameter of the flywheel; degrees is the number of degrees the line must move; and 114 is a constant.

To illustrate: Suppose an intake valve must open 15 degrees after the center line has passed the dead center point and there is no marking. Find the diameter of the flywheel; in this case, say it is 20 inches. Multiply this by the number of degrees—which is 15—and we have 300. Divide 300 by 114 (the constant) and we have 2.631. Therefore, when the center line is moved 2.631 inches beyond the center point, the valve should be open. To mark this distance

on the flywheel, take a flexible rule and lay it on the circumference of the flywheel. Measure back from the center line, or against the flywheel rotation, 2.631 inches, which is $2\frac{41}{64}$. When this new line or mark comes in line with the center line of the cylinders, the crankshaft is in the correct position for the valve to open. The center line and flywheel markings are not always easy to obtain or read, and if the engine is not dismantled it is a difficult matter to get the flywheel diameter and mark it. Let us suppose that a new set of timing gears or chain must be installed and that the valve position is not marked. Therefore, we must find the piston position for the valve operations. Find the length of the stroke and then draw a circle which has a diameter equal to the stroke, as shown in Fig. 15. Mark a point at the top of the circle which represents the center of the crankshaft throw, as at A, and from this point draw a perpendicular line equal to the length of the connecting rod. Since the crankshaft revolves in a circle, the basis of the calculation is 360 degrees. Suppose the intake valve must open 15 degrees past upper dead center, and the engine has a stroke of 6 inches, with a connecting rod 12 inches long. Proceed as shown in Fig. 15. Draw the circle and the perpendicular and mark the point B, which is the 15-degree mark on the circumference. This can be laid off with a protractor, but if one is not to be had, the previous formula can be used to find the distance. From this point on the circumference, measure the length of the connecting rod—12 inches—to a point on the perpendicular line. The distance from the top of the line to the second point will be the distance that the piston must be down from the top when the valve opens. The length of the connecting rod is obtained by measuring the distance between the piston-pin hole center and the center of the connecting rod big-end bearing.

SERVICING TIMING GEARS, CHAINS, CAMSHAFTS, AND PUSH RODS

Opening Up Timing-Gear Case. Whenever any trouble develops with the timing gears or the chain and sprocket gears, it is necessary to remove the timing-gear cover so as to get at the front-end drive. When three-point suspension is used, the timing-gear cover not infrequently carries the front end of the engine. If this

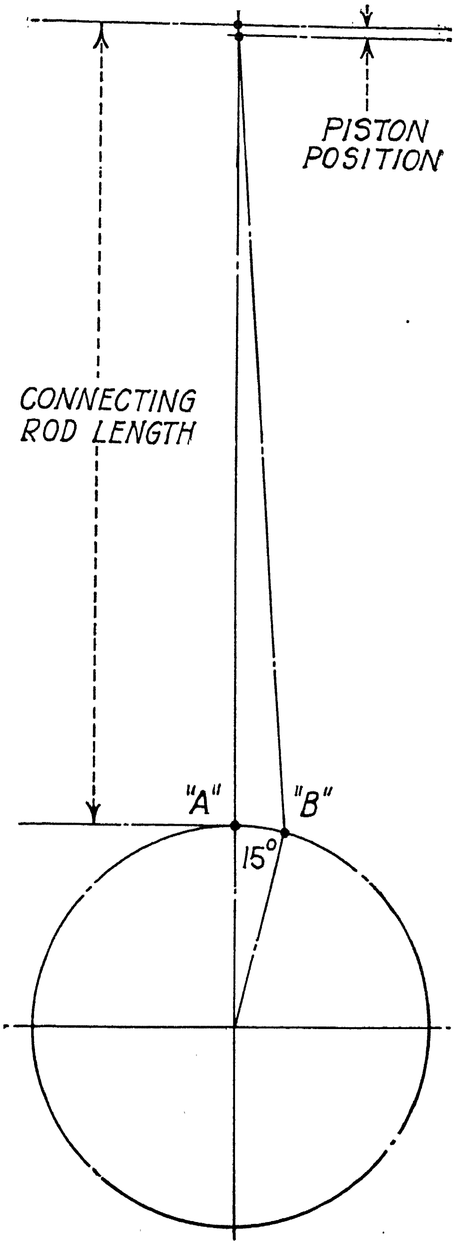


Fig. 15. Relation of Piston Position to Crank Position

is the case, it will be necessary to support the front end of the engine by means of a jack from the under side, as the removal of the timing-gear cover will remove the front support. (This is not always the case but very frequently is true.) When four-point suspension is used, it may or may not be necessary to remove the engine bolts which hold the engine in the car frame. Sometimes it will be impossible to remove the timing-gear cover without raising the front end of the engine for the simple reason that the timing-gear cover must slip forward over the end of the crankshaft and there is not room between the car frame cross member and the engine crankcase. In case it is necessary to jack up the front of the engine for any reason, make very certain to loosen the bolts at the rear engine supports and thus prevent damage to those units because of the strain imposed on them when the front end of the engine is raised.

After the inspection of the engine mounting has been made and the front end of the engine has been placed in position for removal of the timing gear cover, use a speed wrench and spin out the cap screws which hold the timing-gear cover to the timing-gear case. Use care to prevent damage when prying the cover away from the case. It may be possible to save the gasket without serious damage. At any rate no nicks should be placed in the cover or case. It is always possible to make a new gasket from a piece of heavy paper, but it is impossible to secure an oil-tight joint if either the case or the cover has been damaged by prying or pounding. When replacing the cover, make very certain that the gasket is in good condition as an oil leak at this point is sometimes hard to locate and results in draining the engine of oil to the extent that serious trouble may result, such as burned bearings or scored pistons and cylinders.

Inspecting Timing Gears for Wear. With the timing-gear cover removed, the mechanic can inspect the play between the teeth of the timing gears if that form of drive is used. As a general rule, this should not exceed .010 inch. In many cases it will be found that the gears will have worn until there is as much as $\frac{1}{16}$ inch play between them. This is certain to make a very noisy engine. A knock which is very hard to find often exists in timing gears, the usual reason being the amount of play between the teeth of the camshaft gear and the crankshaft gear. A peculiar knock will

sometimes arise which is very difficult to locate and which even experienced mechanics will say cannot be in the timing gear, it being mistaken for a connecting-rod knock. In fact, it does resemble the connecting-rod knock very distinctly. Sometimes it can be located by putting a strain on the accessory shaft or on the camshaft end or at any point where the load on the cam gear from the engine gear will be increased so as to remove the tendency for it to lash back and produce the knock. Another way of determining it is to note whether it is at the front of the engine in the timing case or whether it can be shorted out from some one particular cylinder.

Timing gears of the fabric type may be so badly worn that the teeth are no longer of sufficient strength to carry the load. When such a condition exists, there is no question about the service to be performed. The old gears should be discarded in favor of new ones and as a rule it is a good plan to place on a set of matched gears in order to prevent a howl or gear whine, owing to the fact that a worn gear has been placed into service in conjunction with a new and properly machined gear.

In all work with gears, extreme care must be used to see that no tooth is allowed to become nicked or otherwise damaged. If this happens, rapid wear is certain to occur and a noisy job is certain to result.

Checking Timing Gears for Markings for Engine Timing. Before removing timing gears, the careful mechanic is always certain to inspect the gears or sprockets and chain, as the case may be, for the manufacturers' identification marks. The common method of marking gears is by a center punch mark on the rim of each gear, shown at *A* in Fig. 16. These marks are so placed that when the gears are meshed with marks opposite each other, the engine will be in time. As a general rule it is impossible to assemble a cam gear or the crank gear in more than one position, so the automechanic need only follow the manufacturer's marks in installing the new gears.

Simple as this may seem, it is not a good plan to trust entirely to the manufacturer or the jobber who furnishes the gears. Occasionally mechanics have learned to their sorrow that the factory can slip in this matter and after depending absolutely on the manu-

facturer's marks have found that the engine refused to perform properly. For this reason it is very essential that the mechanic understand what engine timing is and should do for the engine. The properly informed automechanic will not stop at casual in-

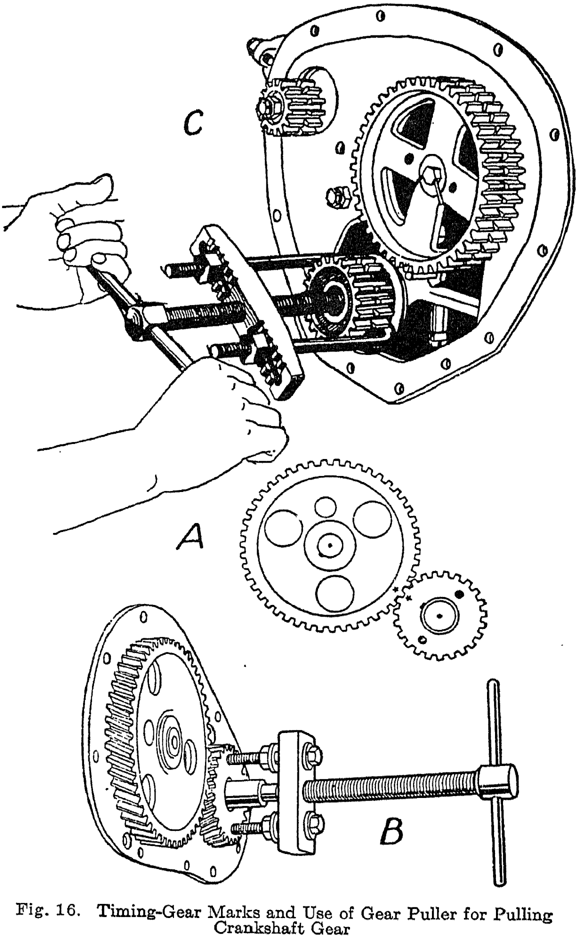


Fig. 16. Timing-Gear Marks and Use of Gear Puller for Pulling Crankshaft Gear

spection of the timing-gear marks, but he will check through the engine and see whether everything is in order. He will open up the inspection plate over the flywheel to see whether the top dead-center marks for cylinders 1 and 4, 1 and 6, or 1 and 8, as the case

may be, are on top dead center when piston No. 1 is on top dead center; and he will also note whether the valve action is occurring in proper time. This is a piece of work which requires but a few minutes and at the same time will show the mechanic that the engine, as it came into his shop, was or was not in proper time and that the gears are or are not properly marked.

In looking for the flywheel markings, the mechanic will usually find a small door, such as that illustrated in Fig. 17, which will open up into the flywheel housing and he will note that there is an

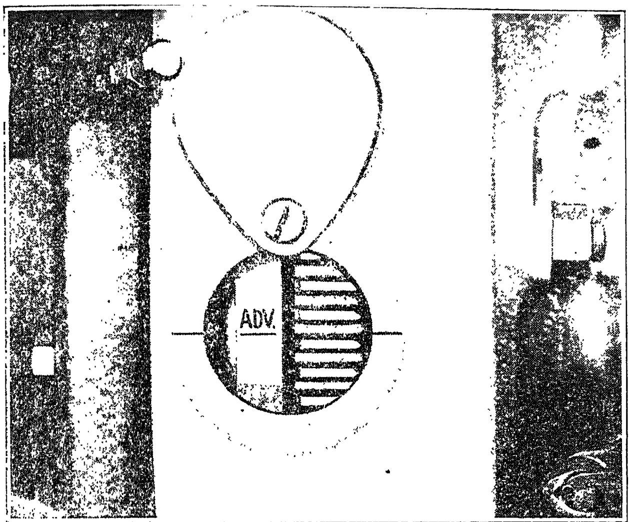


Fig. 17. Buick Method of Marking Flywheel and Providing Inspection Plate
Courtesy of Buick Motor Company

identification mark on the housing itself. The flywheel will have to be turned until the desired markings correspond to the marking on the case. If it has been determined that it is necessary to remove the timing gears and replace them for any reason, the work may proceed along the following lines, but do not confuse ignition timing marks on the flywheel with engine or valve timing marks.

Pulling Timing Gears. In some cases the timing gears are designed so that they are what is termed a slip-fit. This means that they are just snug enough on the end of the shaft that when the locking device is removed they can be slipped over the end of

shaft by hand or by tapping lightly with a rawhide hammer or block of wood. In this form of assembly, the crankshaft gear is usually locked on the crankshaft by a nut, which may be the dog used to engage end of crank handle. When backed off, crankshaft gear may be slipped off over the shaft and key. The camshaft gear in such cases is fastened to the flange on the end of camshaft by cap screws which are prevented from backing out by means of a wire run through the heads of screws. Remove wire and cap screws, and cam gear may be loosened and pulled off by hand.

A common method of assembling engine gears is to drive them into position. The hole in the gear is made approximately .005 inch less than the size of shaft end and when gear is pressed in position, it has what is termed a press-fit. The press-fit, however, is not a sole means of securing the gear, Woodruff keys are also used. In some cases cap screws are used to further secure camshaft gear and a nut is used on the end of camshaft.

Pullers for removing gears pressed on the shaft are of several types. A common one is shown at *B* in Fig. 16. The crankshaft gear has two holes tapped for 3/8-inch U.S.S. threads. Studs of gear puller are screwed into these holes and locked to cross member of puller. The central member or screw of puller is then set in end of crankshaft, pulling gear from end of shaft. Frequently the engine gear is not drilled and tapped for these two bolts. In such a situation ends of puller bolts are bent at right angles, *C*, Fig. 16, and hooked around back of the back portion of engine gear; otherwise the operation is the same.

Installing New Timing Gears. When new timing gears are purchased from jobber or car dealer, compare them with those which have been removed, to see that the proper gears have been purchased. Check up and prove timing-gear marks. Next, place engine in the position which it was in when the timing gear was removed, if for any reason the position of the crankshaft and camshaft have been changed. It is always necessary to make a check and see whether the engine shafts have changed their relation for any reason. Install the crankshaft gear first. This should be done by placing a piece of pipe over the end of the crankshaft and then driving the gear home in a very careful manner, seeing that it is properly aligned. Where only one model is being serviced, the usual practice is to

use a gear pusher, which forces the gear on to the shaft by means of screw pressure.

The next step is to install the camshaft gear. It is rarely possible to install this gear in more than one position as the manufacturer usually provides dowel-pin holes or a key so arranged that only one assembly is possible. At this point the workman will need to exercise considerable care in order to see that the camshaft is not pulled forward and thus make himself considerable trouble. In many cases the camshaft is held in position by means of a boss

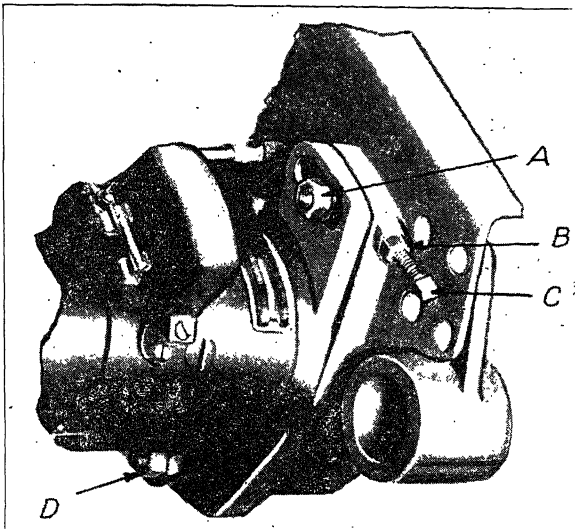


Fig. 18. Provision for Manual Adjustment of Timing Chains

on the timing-gear cover and sometimes by means of a spring and thrust bearing arrangement. If the camshaft is pulled forward, the cam followers may drop back of the cams in such a manner that considerable trouble will be entailed in forcing the cam backward into its normal position. However, there are certain engines where it is altogether proper to allow the camshaft to be pulled forward, since pushing it back does not entail any amount of trouble. Whichever method is followed, the vital point is to see that the engine parts are retained in proper time and that the cam-gear and engine-gear marks are opposite each other. After the gears have been placed

in position and properly secured, make a very careful inspection of the engine time and see that everything checks properly before reassembling the timing-gear cover.

Adjusting Timing Chain. Timing chains wear and stretch. The manufacturers of cars instruct their dealers to adjust the timing chain after about five hundred to one thousand miles of service. In some cases they ask them to have the chain reinspected and adjusted at the end of about two thousand miles more of service, after which the suggestion is usually made that the chain will need to be checked up about once in each ten thousand miles of additional service. Chains which have become worn and stretched until they have considerable sag will come in contact with the timing-gear cover and under certain conditions will produce a scraping noise and under other conditions of operation will give forth a knock as they strike the case.

Where chains are used for front-end drive, the easiest way of adjusting the amount of slack in the chain is to take hold of the accessory shaft or the armature of the generator and rotate it forward and back. If there is considerable play, it will be evidenced by considerable motion forth and back of the accessory shaft.

Frequently the manufacturer will provide an inspection plug in the timing-gear case where the chain drive is used. Remove this plug and insert the forefinger through the plug hole so as to touch the chain. If it can be moved up and down as much as ½ inch, the chain should be tightened. When the timing gear cover is off, the chain may be inspected as shown at *A* in Fig. 19.

Where the automatic adjuster, such as that illustrated in Fig. 11, is used, no adjustment is required on the part of the mechanic. Where the manual type of adjustment is provided, it is usually along the lines of the one shown in Fig. 18, which shows the generator mounting. First, test the chain for play and if it is found necessary to adjust it, back off the locking nuts at *A* and *D*, Fig. 18. In some cases there are three or four of these, in other cases only two. Just release them about one turn. The next step, in the case of the job shown, is to loosen the lock nut at *B* and turn the adjusting screw at *C* until, with the engine running at moderate speed, there is a slight chain hum or growl. Next, back off the adjusting screw *C* until the hum or growl has disappeared and the chain runs quietly.

Lock locking nut *B* and then tighten the locking nuts *A* and *D*.

In many cases there is no adjusting screw such as *C* provided. Under these conditions, all that is necessary is to reach back of the generator and pull it out until the slack of the chain has been taken up. Sometimes this work is done with the engine standing idle, at other times with it running. When there is an inspection hole provided, the inspection plug should be removed and the work should be done with the engine idle, testing the amount of play by means of the forefinger through the inspection hole. The chain should

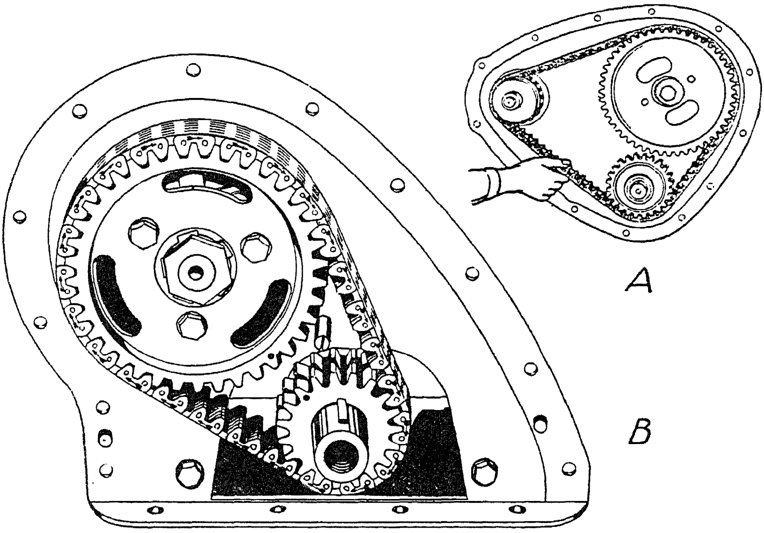


Fig. 19. *A*—Testing Slack in Timing-Chain Drive
B Identification Marks of Timing-Chain Sprockets

usually have ¼-inch up-and-down movement between the sprockets.

After testing the chain and having locked all nuts, test the operation of the engine to notice whether the chain is quiet or not. If there is a howl or chain growl in evidence, the chain is too tight and damage is certain to occur. Under no circumstances should the mechanic use a pinch bar or heavy screwdriver or similar tools to thrust the generator or accessory shaft out to secure an exceedingly tight chain adjustment. It is very likely that the chain will break immediately the engine is placed in operation if such method be followed. The chain must have slack about ¼ inch up-and-down

movement between the sprockets when tested as shown at *A* in Fig. 19. The amount of play allowed for the type of chain drive shown at *B* would not need to be quite so much—⅛-inch movement perhaps being sufficient—but this type is not always adjustable.

Checking Timing Chains and Sprockets for Engine-Timing Marks. The matter of installing new timing gears is comparatively simple compared to that of installing a new timing chain and timing-chain sprockets. The workman who is totally unfamiliar with the principles of engine timing will sometimes be able to get by in

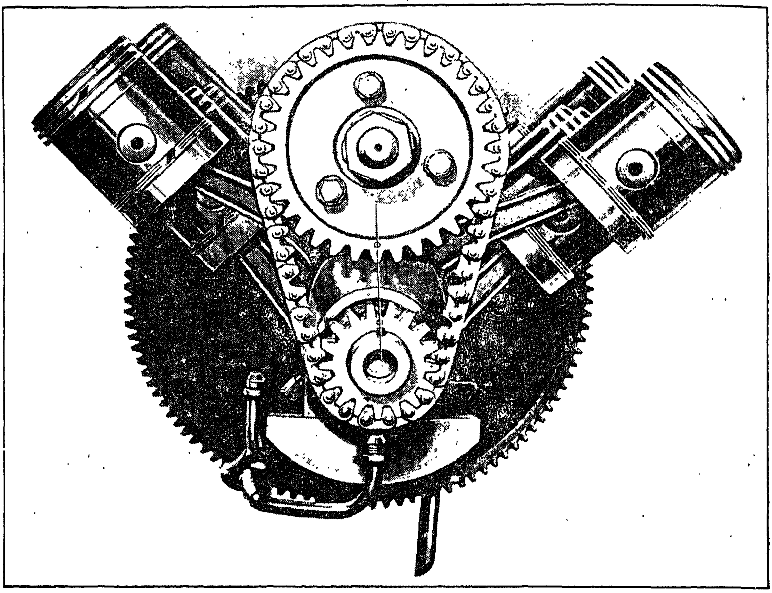


Fig. 20. Timing Marks on Sprockets of a V-8 Engine

installing timing gears if he simply follows the timing-gear marks. On the other hand, some timing-chains are not marked and timing-chain sprockets are not marked. Under these circumstances it is absolutely essential that the mechanic know his engine theory and be able to place the crankshaft and camshaft in proper position for correct timing of the valve operation. It is presumed, of course, that every mechanic does know this. At the same time, no automechanic, however experienced, will overlook the markings when he is working on the front-end drive of an engine. *B* in Fig. 19

shows a very simple type of marking used with reference to chain sprockets. This is very similar to that of the timing gears, the marks being so placed that they will be opposite each other and in line between the centers of the crankshaft and camshaft. Where the type of chain drive is similar to that at *A* in Fig. 19, the marking is not so simple. Some gear manufacturers specify that there shall be a certain number of teeth of the timing chain between identification marks placed on the camshaft and crankshaft gears. The number of these teeth is sometimes cast or stamped on the timing-gear housing so that it is always available if the workman will look for it. Certain cars use center-punch marks on the pins of the timing chain. These center-punch marks or other marks are a certain number of chain links apart. The chain sprockets, Fig. 20, are also provided with marks and if the marks on the chain are brought into position with reference to those on the sprockets and the assembly completed, it will be found that the engine is in time.

When working on timing chains with the idea of either replacing them or checking the engine timing, while the timing-gear cover is removed inspect the markings so as to know how to identify them. When purchasing new timing chains from the dealer, ask him for the identification marks and how the timing is to proceed. These steps are all taken as a matter of precaution. The final proof of the work is always the exact knowledge which the mechanic has as to the operation of the four-cycle engine. If he has this knowledge and knows the point at which the exhaust valve closes and the intake valve opens, and will then check the tappet clearance and set up the engine according to this knowledge, there will be no question about its being in proper time. The mechanic appreciates that whatever markings are put on are for his guidance and his help. He also appreciates the possibility of some one slipping in placing on marks. Therefore, he depends solely on his exact knowledge of engine timing as a final check on his work.

Removing Timing Chain. The timing chain may be removed by finding the special joint which is frequently used in assembling these chains. Sometimes no special link or joint is used and under these circumstances the only way to open the chain is by the use of a grinder such as shown at *A* in Fig. 21. This means that the chain

will have to be removed without opening it. If it is a short chain without any manual or automatic adjustments, it is very likely that the cam gear will have to be pulled in order to remove it. Where this method is necessary, the cam gear is usually locked in position by means of several cap screws, similar to those shown at *B* in Fig. 19.

Testing Timing Chain. Timing chains, after being removed and opened, are tested to see whether they are worn more than is safe for re-use. There are two methods of doing this. One is to lay the chain flat on the bench top and twist it to the side to see how much of an arc can be thrown into it. If there is only a slight arc, the chain does not have much wear. If there is a considerable arc, it would indicate that the wear was greater than would warrant the reuse of the chain. Perhaps a more definite test is to lay the chain flat on the bench top and push it from each end until the slack is taken out. Make a mark on the bench top and then pull the chain outward until all slack is again taken up. If the difference in the chain length is more than $1\frac{1}{4}$ inches, it is recommended that the chain be replaced. A visual inspection of the chain will show whether links are broken. If links have been broken and the chain is otherwise badly worn, of course it needs to be replaced in order to prevent a breakdown of the car when on the road.

Shortening Timing Chain. The usual practice is to provide timing chains with what is termed as hunting links, as shown at *D* in Fig. 21. After a chain has worn and stretched the amount of one link, it will be seen that the removal of the hunting link will shorten the chain up to its original length. That is the reason the hunting link is provided by the chain manufacturers. Not all chains are provided with hunting links, however, and when the chain which is not provided with one is to be shortened, it is necessary to remove two of the regular links and install a hunting link.

When opening a chain which is not provided with a special link for opening, it is necessary to grind off two of the seat pins, as shown at *A* in Fig. 21. These pins are indicated at *F* and *G*. The chain will then be separated as shown at *B*. After the hunting link has been removed, the chain is reassembled as shown at *E*, using a new seat pin. Always use the old rocker pins and new seat pins, being certain to install them as shown at *C*. If the rocker

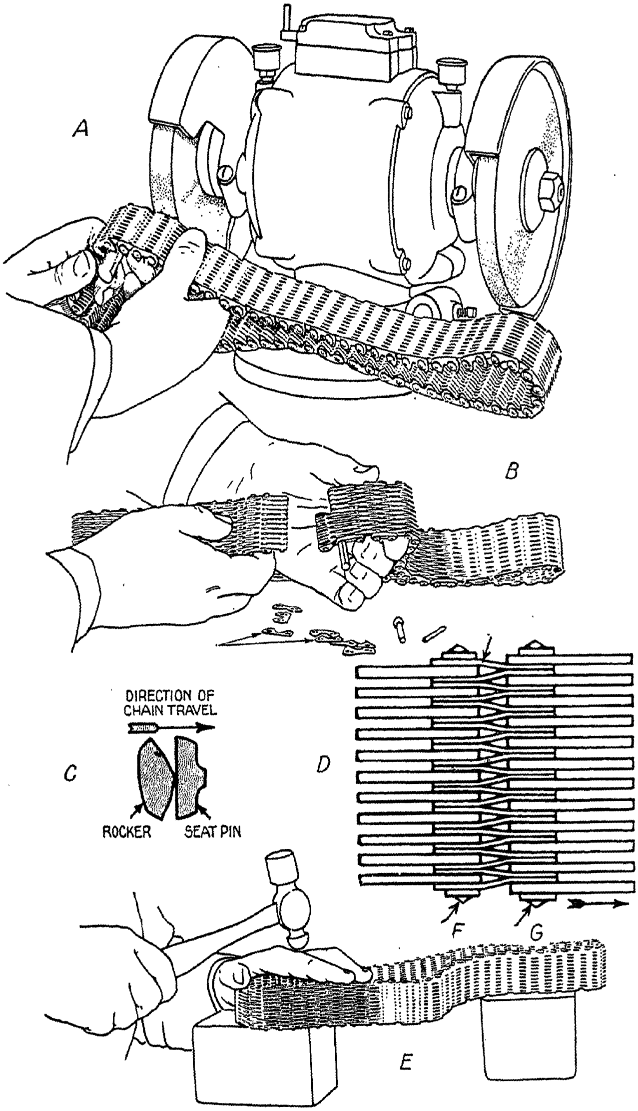


Fig. 21. Method of Removing Hunting Link and Refitting Shortened Chain

pin should be reversed, the chain would not be quiet and it is very likely that it would break in a short time.

Installing Shortened Chain. After the chain has been shortened, the engine is timed and the chain installed just as for a new chain. Sometimes mechanics will remove the hunting link when not sufficient wear has occurred in the chain with the result that it is impossible to secure a quiet operating job, the chain being so tight that it hums. Under these circumstances, there is only one remedy and that is to replace the hunting link, otherwise the chain will be broken and serious damage may result in the front end of the engine. As a rule, there is enough adjustment provided on a chain that it may be worn a bit more than the length of one link and still be kept in proper running adjustment. After the hunting link has been removed, the adjustment will have to be set forward and, as wear occurs, it will be possible to take it up again until such time as the chain is practically worn beyond further use.

Checking Up on Camshaft. Camshafts are not subject to great depreciation, as a rule. Sometimes the cams themselves will become scored and in rare cases bearings will become worn to a point where they are noisy. It is impossible to do anything if the bearings have become worn other than replace the shaft with one in normal condition, since the bearings are reamed into the crankcase metal in most cases. In those cases, such as the Ford Model T and certain other jobs, the camshaft bearings are renewable and where this condition is found, it is advisable to have them replaced to eliminate noise. This is so seldom necessary that it is almost a negligible proportion. A more usual cause of camshaft noise is the amount of end play, which is sometimes removed by end-play adjustment which must be sought for on the engine or the camshaft may have become sprung, resulting in a whipping action as it is rotated.

When testing the camshaft for misalignment, place it between centers in the lathe or on the V-block on the test bench. Mount the indicating gauge so as to indicate the truth of the center bearing. If the test shows the camshaft to be sprung more than .002 inch, the usual practice is to replace it with a new one or to have it straightened until it does check within this limit. If the cams are scored, as indicated at *A* in Fig. 22, it is necessary that they be dressed down

by means of an oil stone or a piece of fine emery cloth, preferably 0 or 00, mounted on a board. The camshaft may be mounted in a lathe and turned over at a slow rate of speed, while the mechanic uses the oil stone or emery cloth board to grind and polish the scores out of the cam face. Use exacting care in doing this work to see that the scratches are ground out and not into the cam face. If it is necessary to remove more than a slight amount of metal, it will be found that the case hardening of the camshaft has been penetrated. This is not likely to be the case, but must be borne in mind since if the case hardening is penetrated, the life of the cam would be very short when placed in service.

When the roller type cam followers are used, it sometimes happens that the roller will start to cut a track in the cam. This is especially likely to occur if it happens that the camshaft got through the factory without proper heat-treating. Under such circumstances it is useless to attempt to put the camshaft in such shape as to secure a quiet job. The only remedy is to discard the camshaft and replace it as well as the rollers and roller pins with new ones so that a proper assembly is secured, which will be equal in operation to that of a new engine.

Polishing Cam Followers. When the adjusting screw of the valve lifters is set with too close clearance under the valve stem or push rod, the valve lifter is forced down on the cam at each explosion within the engine cylinder. This results in a very great load on the face of the cam follower and scoring of the cam follower is almost certain to occur, as is shown at *B* in Fig. 22. This is a condition which results in the scoring of the cam, as shown at *A*. In order to remove these score marks, the mechanic may use a sheet of fine emery paper, preferably 0 or 00, tacked on to a board or held on the face plate. Use a rotary motion, as indicated at *C*, to polish out these scores. Continue the work until no scratches whatever are to be found.

Lubricating Timing Gears and Timing Chains. Formerly it was rather a common practice to separate the timing gear compartment from the engine crank case. This has largely been superceded by the method of leaving the timing gear or timing-gear case open to the crank case and lubricating the front-end drive by means of the engine lubricating oil, which is forced to the front end through

tubes or other channels, so that a stream of oil flows on the timing gears or on the timing chain. Where this method is used, it is not necessary to pay any particular attention to the lubrication of the front-end drive. In certain cars where the timing gear compart-

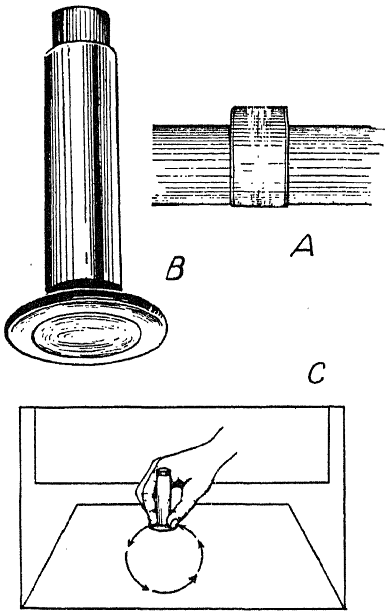


Fig. 22. *A*—Scored Cam
B—Scored Cam Follower
C—Polishing Scored Cam Follower

ment is separate from the crank case, a special lubricant may be needed. It is very likely that this will only be found on the older cars and the manufacturer's specifications will indicate the type of oil to use for this drive. Usually it is a heavier oil, more in the nature of the transmission oil, known to the trade as 600-W.

FORD "V-8" ENGINE

The Ford eight-cylinder V type engine, Fig. 23, has a 90-degree angle between the cylinders, which gives the engine an even power impulse. The engine has a bore of $3\frac{1}{16}$ inches with a stroke of $3\frac{3}{4}$ inches, and the taxable horsepower rating is 30 horsepower.

Lubrication is by special pump to camshaft and crankshaft bearings, with splash for the piston and cylinder. The oil pressure is regulated by a valve of the spring and ball type.

The crankshaft is of the counterbalance type with two connect-

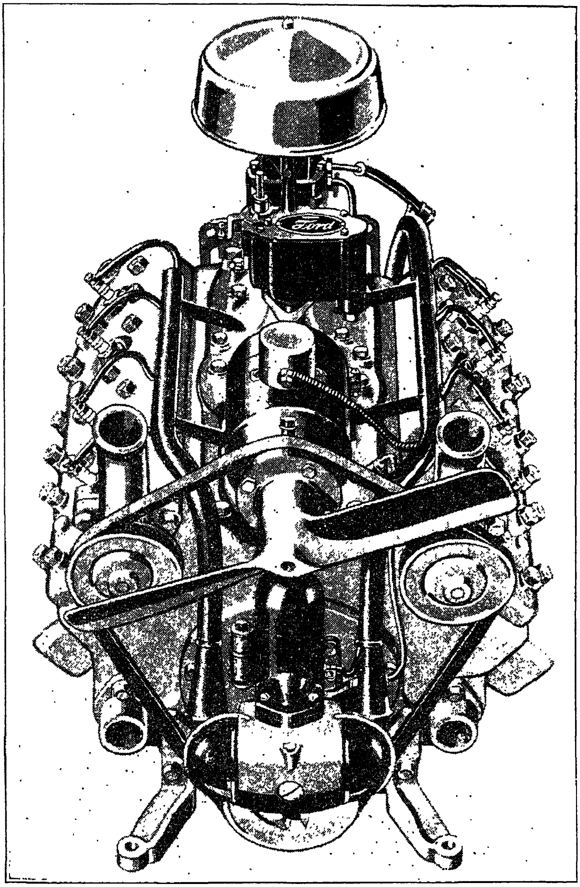


Fig. 23. Ford "V-8" Engine

ing rods bolted to each crankpin, and is drilled for lubrication. The firing order is 1R, 1L, 4R, 4L, 2L, 3R, 3L, 2R, when the engine cylinders are numbered 1 to 4 from front to rear on both sides. Fig. 24 shows the Ford method of marking the cylinders and the firing order.

The cooling system is by thermo circulation and is helped by the

operation of two centrifugal pumps located on each cylinder block at the front and at the lower end of the outlet hose from cylinder to radiator.

The cylinders are of the L type, the valve seat being so arranged that the valve stems are at an angle to the cylinder.

The connecting rod bearings are rather peculiar in construction, in that there is a floating babbitt bearing between the rods and crankshaft, which has a clearance of .002 inch to .004 inch on the shaft, and .0015 inch to .003 inch between the connecting rod and the outside of the bearing. Bearing adjustments can only be made

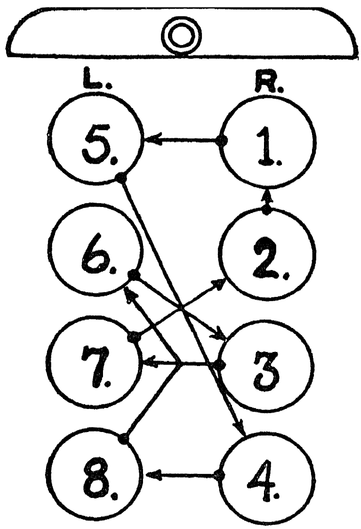


Fig. 24. Ford V-8 Firing Order

by replacing this bearing insert. The side clearance between the rods is .001 inch to .002 inch.

Pistons and connecting rods are removable through the top of the cylinder, and the pistons are fitted with a clearance of .0005 inch to .003 inch and should be installed with the split skirt towards the right as viewed from the front of the engine, or with the arrow on top of the piston pointing to the radiator.

The main bearing construction allows the removal of the upper half of the bearing without the entire dismantling of the engine, and no shims are used in any of the bearings.

There are two $\frac{3}{32}$-inch compression rings and one oil ring $\frac{5}{32}$ inch wide. The clearance of the ring in the piston groove, which allows free movement for the expanding ring in the groove, is .001 inch to .0015 inch, while the gaps are as follows: .010 inch to .012 inch for the top ring; .008 inch to .010 inch for the next ring; and .005 inch to .008 inch for the bottom ring. The side of the ring with the name "Ford" stamped on it should be placed toward the top.

The piston pin, which has a diameter of $\frac{3}{4}$ inch, is held in the piston with snap rings. The piston pin should be a handpush fit in the connecting rods when cold. To check the fit of the piston

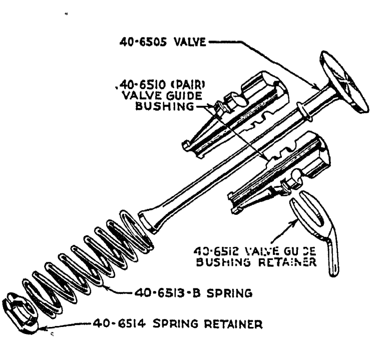


Fig. 25. Ford Valve, Valve Guide, Retainer, and Spring

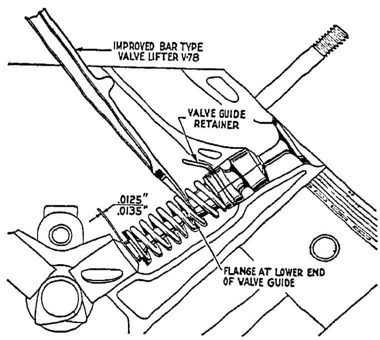


Fig. 26. Removing Ford V-8 Valves

pin in the piston, it is suggested that the piston be placed in boiling water for ten minutes, and then the piston pin should be a hand-push fit in the piston.

The valve stem and push rods are individual units. The ends of the valve stems, Fig. 25, are larger than the main stem to form a seat for the valve spring collar. The valves are not adjustable, being made of special steel which is heat resisting. The clearance is correctly set at .013 inch when cold on the inlet and .015 inch on the exhaust.

To remove the valves, it is first necessary to compress the spring and then remove the spring collar, after which the spring is allowed to drop down. Next, raise the valve sufficiently to allow

the guide to be driven out of the cylinder blocks, after which the valve may be lifted out. The angle of the valve seat is 45 degrees, and the width of the seat is 3/32 inch.

When grinding in the valves, the vacuum cup type grinder is used, and the guide must be replaced while the valve is being ground. Care should be taken to see that the guide is not cocked when replaced in the cylinder, as this will of course throw the valve out of alignment with its seat.

Ford V-8 Valve Construction. The improved valve, valve spring, and valve guide design, permitting better valve action during

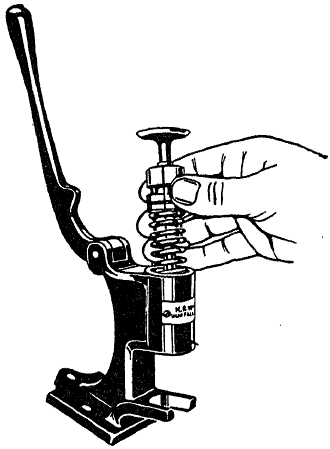


Fig. 27. Placing Valve Assembly in Fixture

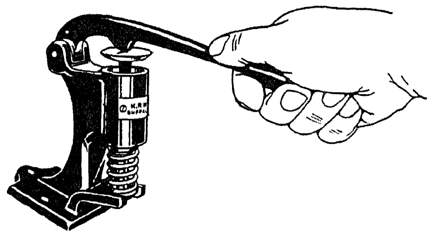


Fig. 28. Compressing Valve Spring to Remove Retainer

the entire speed range of the V-8 engine is shown in Fig. 25 disassembled and in Fig. 26, in the position in the block. This construction permits the removal of the valve, valve guide, valve spring, and valve spring retainer, from the engine, as an assembly, after the valve guide bushing retainer has been removed.

The V-8 bar type valve lifter has been redesigned so as to make it equally adaptable to both the new and old valve design. The bar type valve lifter is inserted through the valve spring to the flange on the lower end of the valve guide bushing, as shown in Fig. 26. This permits the valve guide bushing to be pulled down sufficiently to remove the valve guide bushing retainer, after

which the assembly can be withdrawn from above as an assembly.

A bench fixture V-130 is available for the assembly and disassembly of these new type valves on the bench. The valve assembly is placed in the fixture as shown in Fig. 27, after which the spring is depressed, as shown in Fig. 28, and the valve spring retainer can be removed. The fixture is so designed as to make it impossible to compress the valve spring sufficiently to reduce its tension, the head of the valve acting as a stop. The earlier models have the valves removed by means of the valve guide remover shown in use in Fig. 29. Checking Ford V-8 valve clearance is shown in Fig. 30.

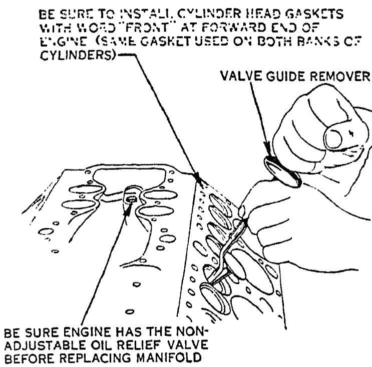


Fig. 29. Removing Valves from Early Ford V-8 Engine

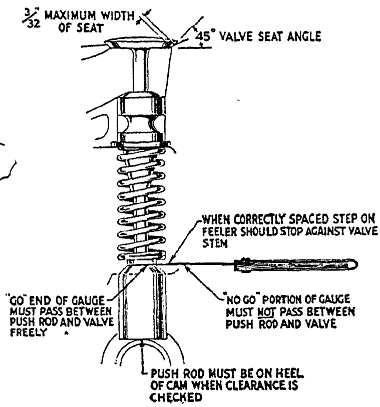


Fig. 30. Checking Ford V-8 Valve Clearance

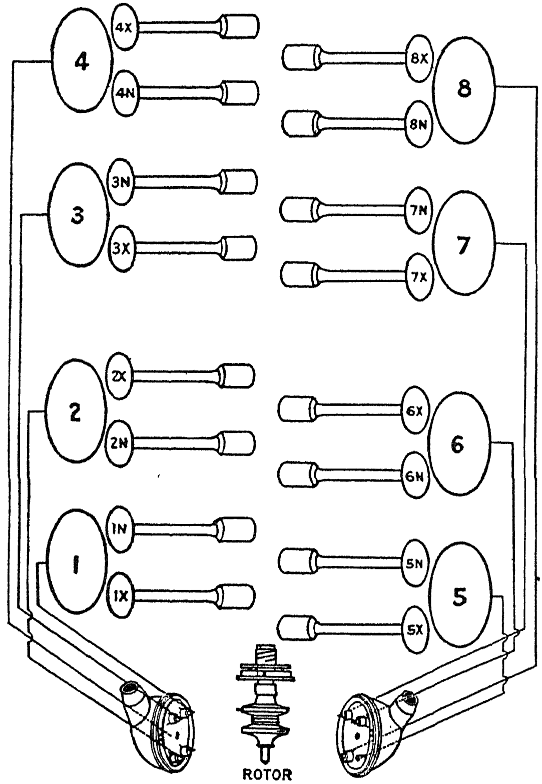
Grinding Ford V-8 Valves. When the cylinder heads are removed, one of the combinations of valves shown in the first column, Fig. 31, will be found to be wide open. For example—when the heads are removed, if No. 8 exhaust and No. 5 intake valves are found to be full open, the key would be the letter *B* and the six valves listed in the group on the same line under the heading, "valves to grind," may be ground. In front of each of the combinations of valves in the first column a letter has been placed. This letter is the key for the next crankshaft setting.

After grinding the six valves designated, turn the crank until the next combination behind the letter *B* is full open. In this position you will find six valves may be ground, after which the next *B*

DATA FOR GRINDING VALVES

KEY: N=INTAKE X=EXHAUST

	VALVES OPEN	VALVES TO GRIND
A	4X+1N	3X–8N–6N–7X–3N–2X
B	8X+5N	1X–7N–6N–7X–3N–2X
C	6X+4N	5X–2N–1X–7N–3N–2X
A	3X+8N	1X–7N–5X–2N–4X–1N
B	6N+7X	5X–2N–4X–1N–8X–5N
C	3N+2X	4X–1N–8X–5N–6X–4N
A	1X+7N	8X–5N–6X–4N
B	5X+2N	6X–4N–3X–8N
C	4X+1N	3X–8N–6N–7X

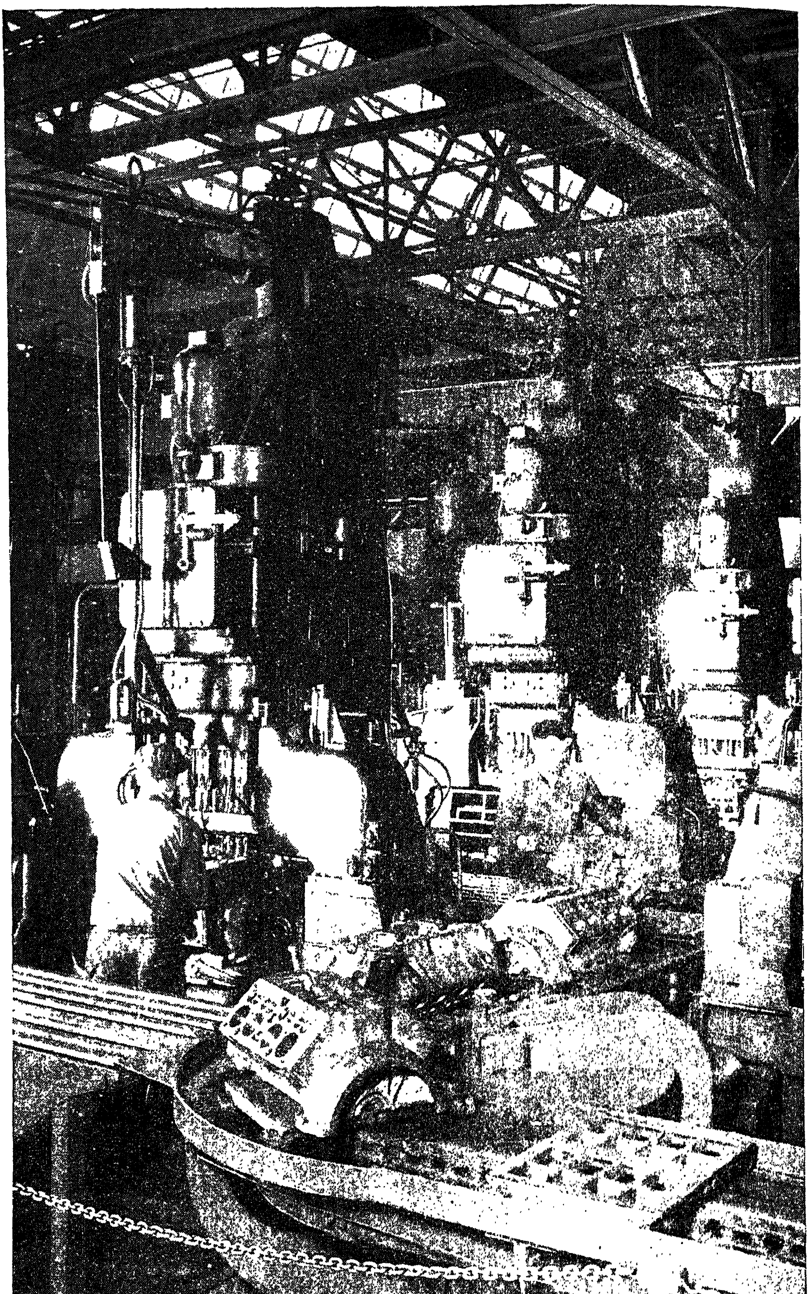


FIRING ORDER 1-5-4-8-6-3-7-2

Fig. 31. Ford V-8 Valve Guiding Chart

combination is used, namely, No. 5 exhaust and No. 2 intake. In this position four valves may be ground. Thus all the valves are ground with but two part turns of the crank, yet each of the push rods was on the heel of the cam when the valves were being ground and clearance set.

If the original combination of valves had been 4-X and 1-N the letter *A* would be the key for each new position. Clearance for all V-8 valves should be set to .0125″ to .0135″. The method of checking this is shown in Fig. 30.



MOTOR BLOCKS UNDER MULTIPLE DRILL PRESSES
Courtesy of Ford Motor Company

VALVE-OPERATING MECHANISMS

LINCOLN HYDRAULIC VALVE LIFTER ASSEMBLY

To insure quietness of operation, the clearance between the valve lifters and valves is maintained automatically at a zero point in the Lincoln hydraulic valve lifters, Fig. 1.

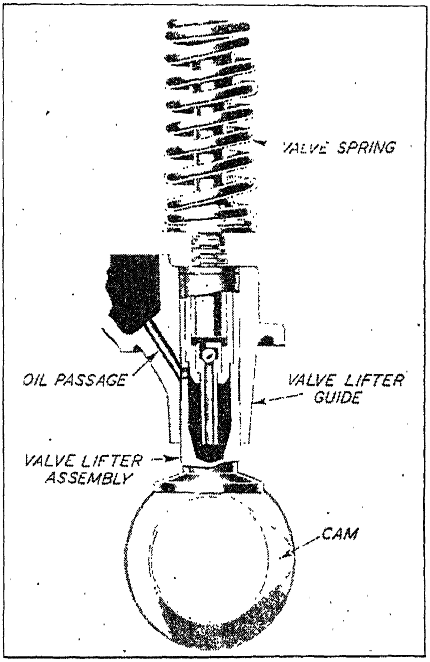


Fig. 1. Lincoln Hydraulic Valve Lifter Assembly
Courtesy of Ford Motor Co.

Valve lifters are self-adjusting to compensate for the expansion and contraction of the valve stems. Oil under pressure is supplied into the valve lifter assembly from the main oil manifold.

During the short interval that the valve is off its seat, there is

slight oil leakage which occurs in the valve lifter. This is necessary to compensate for any expansion of the valve stem, which naturally occurs when the valve stem becomes heated because of engine operation.

The leakage of oil is replenished when the valve closes, and this eliminates clearance between the lifter and valve stem. Valve operation is quiet, and is constantly maintained in the manner described. No noise occurs because the valve lifter assembly is always in contact with the bottom of the valve stem.

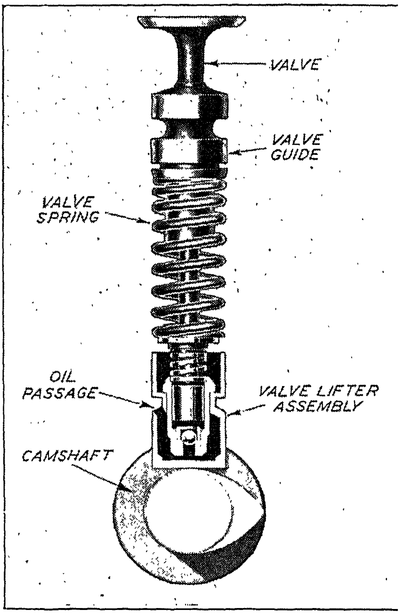


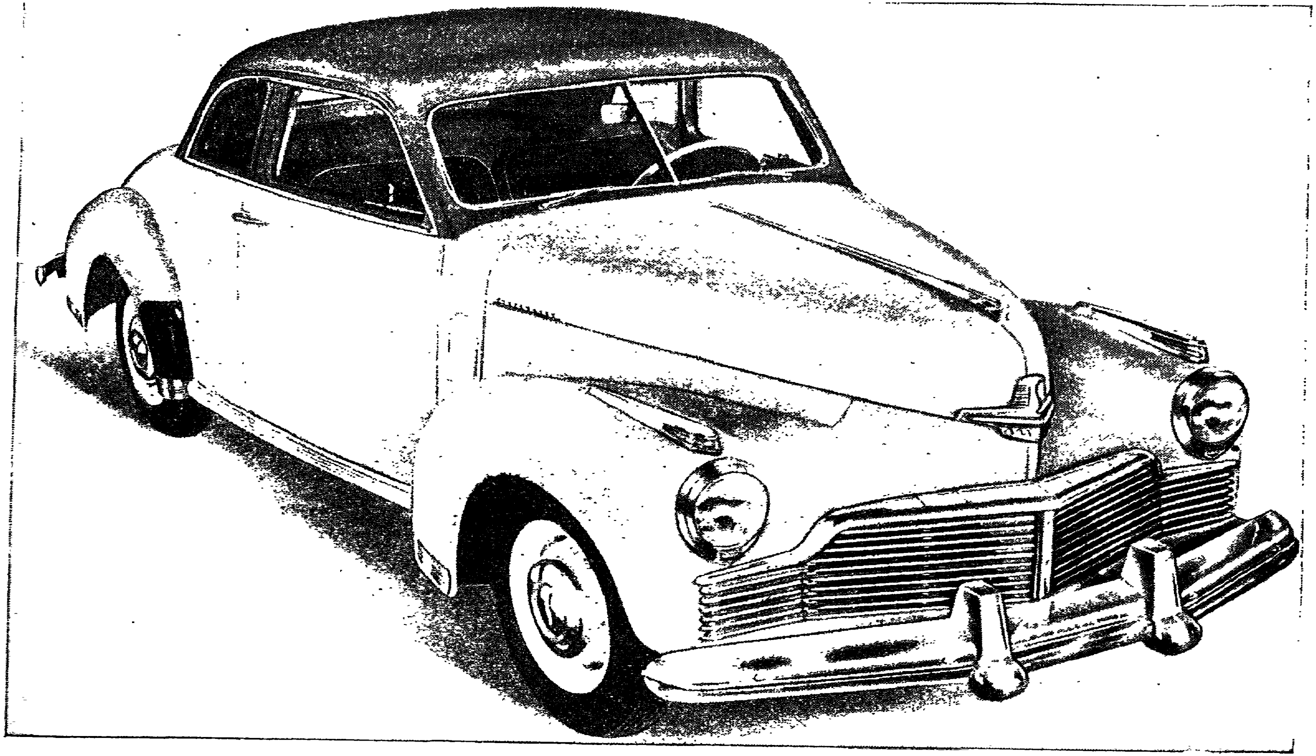
Fig. 2. Lincoln-Zephyr Hydraulic Valve Lifter Assembly
Courtesy of Ford Motor Co.

There is no necessity to ever check valve clearances in the Lincoln engine.

LINCOLN-ZEPHYR VALVE LIFTER ASSEMBLY

The principle of operation of the Lincoln-Zephyr valve lifter assembly, Fig. 2, is similar to that described in respect to the Lincoln engine, Fig. 1.

There is however a slight difference in the construction of the assembly and also in the way that the oil is supplied into the valve lifter assembly. In the Lincoln-Zephyr assembly, the oil is supplied by pressure into the valve lifter assembly from auxiliary oil lines which are fed from the oil manifold. While in the Lincoln, oil under pressure is supplied into the valve lifter assembly direct from the main oil manifold.



1946 STUDEBAKER CHAMPION WITH "SKYWAY" STYLING
Courtesy of the Studebaker Corporation

CONNECTING RODS

FUNCTION AND DESIGN

The purpose of the connecting rod is to transmit the power developed by the combustion of the gases in the combustion chamber to the crankshaft, and with the aid of the crankshaft to change the reciprocal motion of the piston to rotary motion, which is necessary

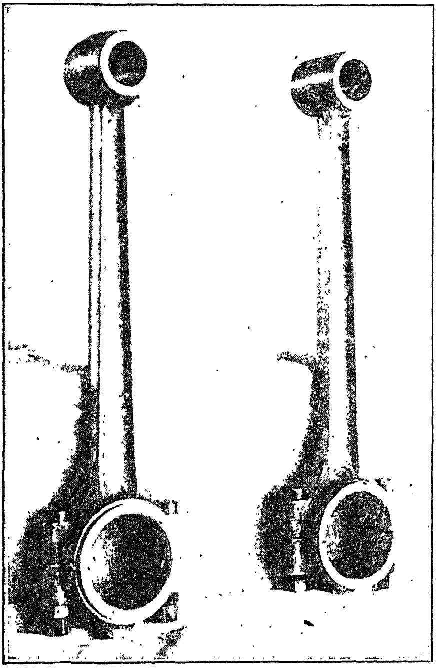


Fig. 1. Rod at Left Is Representative of Heavier Construction
Rod at Right Has Been Lightened by Machinery

to drive the automobile. The connecting rod has to withstand two strains which are set up by two conditions of its operation. A compressive strain is set up by the weight and inertia of the reciprocating parts, and the other strain is the centrifugal force of the revolving crankshaft transmitted through the rod. Therefore, the design of the connecting rod is an important feature in its manufacture. The

explosive pressure is also a compressive pressure which amounts to more than the pressure set up by the reciprocating parts.

The length of the rod is also important. It has been found that the shorter the rod, the greater the side thrust on the cylinder walls, owing to the greater angularity of the rod. A long connecting rod will reduce the wear in cylinder and piston. A shorter connecting rod is lighter, and as weight is an important factor in the present-day cars, it appears to be the correct installation. The length of connecting rod is in proportion to the radius of crank throw, which should be about three and one-half times the radius.

The connecting rods illustrated in Fig. 1 are typical of the H-type or I-beam design of connecting rods. While the former practice of babbitting the big end of the rod was one of having the babbitt metal sweated onto bronze backs, which in turn were mounted in the connecting rod, there has been a tendency to get away from this type of construction. The auto mechanic servicing automobile engines will come in contact with many rods in which the babbitt metal has been sweated or spun directly into the big end of the rod. When this is done, the usual method is mounting the connecting rod in a machine designed to cause it to spin rather rapidly while pouring the molten babbitt into the bearing. This way the centrifugal force causes the metal to be thrown outward around the bearing surface until a proper depth of bearing metal is obtained.

In other cases the connecting rod is set up and the metal is poured into the rod, allowing more metal than the desired thickness to be added. The machining operation in this instance is one of having the rod in position for boring out the big end to the size designed to fit the crankshaft. When doing this work, the cap is bolted tightly to the upper part of the rod and the boring operation completed. When boring the rod, it may be held rigid and the cutter revolves, or it may be mounted on the face plate and revolved about the cutter. This depends upon the type of equipment used for boring out the rod.

Oldsmobile Connecting Rods. Fig. 2 illustrates the 1937 Oldsmobile connecting rods. The bearing shells lying in position near the big end of the rod are of thin-wall, steel backed, babbitt lined type. They are held in place in the big end of the rod by means

of extensions which are stamped in the edge of the bearing shells and located in machined notches in both the caps and the rods.

A cross section of the connecting rod, Fig. 2*A*, as cut through the piston pin shows the location of these bearing shells in the big end of the rod and an oil hole drilled from the top surface of the upper connecting rod running all the way through to the piston pin. This view also shows the method of locking the piston pin in position.

It will be noted in Fig. 2 that each of the thin bearing shells has

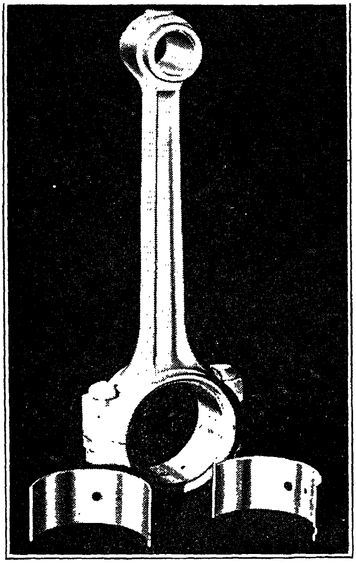


Fig. 2. 1937 Oldsmobile Connecting Rod
Courtesy of Olds Motor Works

several oil holes in it. One of these oil holes is provided so that when the thin shell in the upper half of the rod comes into a certain position of crankshaft travel the smaller indexes with the oil hole in the crankshaft as the piston approaches top dead center on each piston stroke. This allows a spray of oil to be thrown out of this oil hole spraying the exposed cylinder wall with additional oil.

The piston pin bushing is of the thin wall split type, being pressed into the upper end of the rod from either side, after which it is bonded in the rod with a burnishing bar, the final machining operation being one of diamond-boring.

Aluminum Connecting Rods. Since part of the connecting rod weight is a reciprocating weight, as well as all of the pistons, rings, and pins, it stands to reason that the lighter the connecting rod, the less the weight to be stopped and started at the end of each stroke. Naturally the less the reciprocating weight, the less the vibration

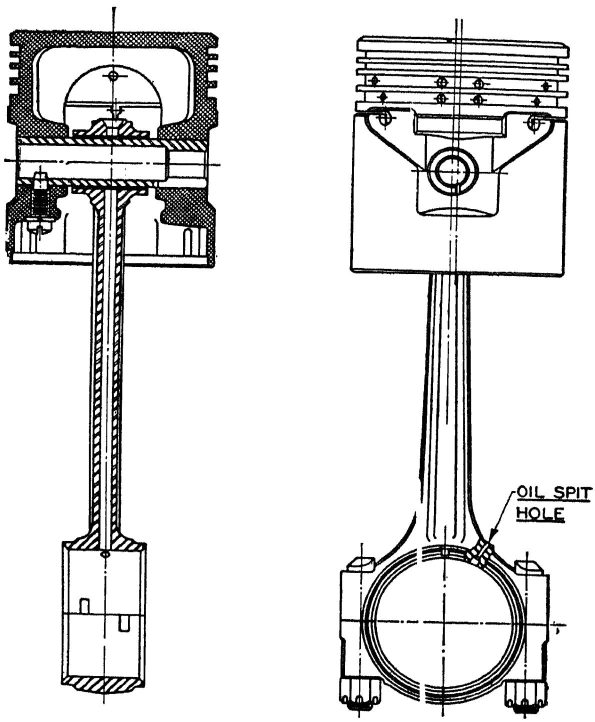


Fig. 2A. Oldsmobile Rod and Piston Assembly
Courtesy of Olds Motor Works

induced within the engine and the less the power losses. The aluminum and aluminum alloy rods are light and satisfy this feature of engineering very well. Some racing engines are equipped with aluminum alloy (Lynite) rods similar to the one shown in Fig. 3. It will be noted that this rod is very similar to the usual design of drop-forged-steel connecting rods.

Connecting-Rod Bearings. *Usual Type.* Connecting rods have two forms of bearings, due to the difference in their service. At the upper or piston end, the bearing is usually a high-grade bronze

tubing, machined all over and pressed in place. In place, it generally has a central oil hole drilled through rod and bushing, and then a couple of oil grooves are scraped in by hand to start from this hole and distribute the oil outward in both directions on its inner surface.

At the lower or, as it is usually called, big end, the connecting

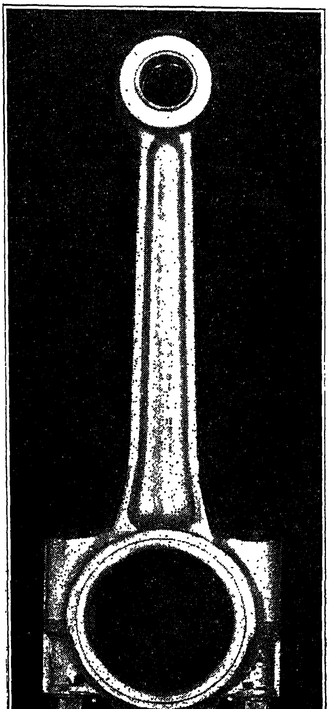


Fig. 3. Lynite Connecting Rod

rod must have a better bearing. This end is bolted around the crankshaft pin and must sustain high rubbing speed as well as the load of explosions. Bolting it on and the need for removing it occasionally call for a form which is split horizontally. Generally, this bearing is of high-grade bronze or steel with a softer or babbitt central lining which can be replaced easily and quickly. The harder back will sustain the stresses of bolting up tight and stand up under the constant pounding, while the softer and renewable center takes all

ordinary wear. These bearings are fitted with great care. They are usually drilled for oil, and grooved to distribute it.

Eight- and Twelve-Cylinder V Types. The eight- and twelve-cylinder V-type engines have altered the design of connecting-rod bearings somewhat, so that two connecting-rod big ends work upon one crank pin, that is, an eight-cylinder V-engine uses a four-cylinder form of crankshaft with two connecting rods on each pin.

Since the chief idea of utilizing the V-type motor is to have the engine confined within a smaller area, so as to give more space to passengers in the car body, for the same length of wheel base, it

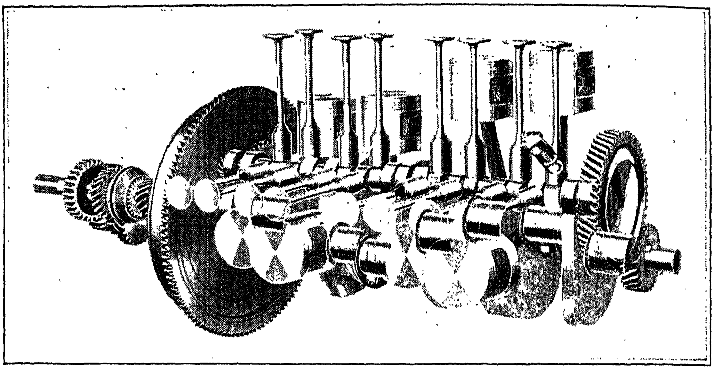


Fig. 4. Ford V-8 Engine
Courtesy of Ford Motor Company

holds that space must be conserved within the crankshaft design particularly with reference to the crankpins. At the same time it is necessary to have a certain area within the rod bearing to distribute the weight coming on to the shaft from the load of the explosion so as to prevent undue wear of the bearing material. To secure this larger area, the common practice is to make the crankshaft pin of greater diameter and then confine the width of the bearing within rather close limits. Thus we find that in the side-by-side construction of big end connecting rod bearings on the crankpin, the over-all length of the pin is not extremely great.

The big end of the connecting rod is always split to facilitate removing and assembling the rod to the crankshaft. In the case of certain engines, it has been found necessary to cut the big end of the connecting rod on an angle so as to have a smaller width when

removing the crankshaft and piston assembly through the head of the engine. Certain models of the Cadillac utilize this type of construction.

Ford V-8 Connecting Rod Construction. Fig. 4 illustrates a phantom view of the crankshaft, timing gears, camshaft, flywheel, valves, pistons, rods, and part of the transmission of the Ford V-8. These parts are shown in their relative positions. It will be noted that the method used for assembling the big ends of the connecting rods to the crankshaft, which is shown in light phantom view, is side-by-side construction. However, the Ford construction is distinctly different in one point from other side-by-side rods.

In order to afford larger bearing surface for the weight carrying requirements, the Ford Company utilizes a split bushing which is babbitt lined on both its exterior as well as its interior surfaces and is allowed to float within the big ends of the connecting rods as well as on the crankshaft pin.

The formula for coating these split bushings with bearing metal has not always been the same in the Ford construction. For instance, certain of the truck models have utilized bearing metals designed to give longer life under hard service. Likewise, in the case of the crankshaft, those which are cast rather than drop forged are usually of a harder texture designed to give longer life. Irrespective of the type of bearing metal used, it is always softer than the steel or cast iron against which it bears and is protected in its contact against these metals by a film of oil on its inside and on its outer surfaces. The general plan of assembling the reciprocating units of the Ford engine are also illustrated in Fig. 8 in the valve-operating mechanism section of this volume.

TYPES OF CONNECTING-ROD OILING SYSTEMS

There are two distinct types of connecting-rod oiling systems. One of these is the splash and the other is the forced feed. Both systems have been in use for a number of years, but the forced feed system has the advantage in that it is more positive in its action. Each system has its own peculiar advantages.

With the splash system, the crankshaft is not drilled. There is a dipper, Fig. 5, provided on the bottom of the connecting-rod cap, or one of the connecting-rod bolts may serve this purpose, for

splashing into the oil in the oil pan or trough (upper level), thus throwing the oil into the bearings through a hole drilled into the cap, splashing it up into the crank case and over the rod. Capillary attraction plays a very important part, carrying the oil into the bearings.

Every mechanic has had the experience of oiling a line shaft and knows that by dropping a few drops of oil on one end of a line-

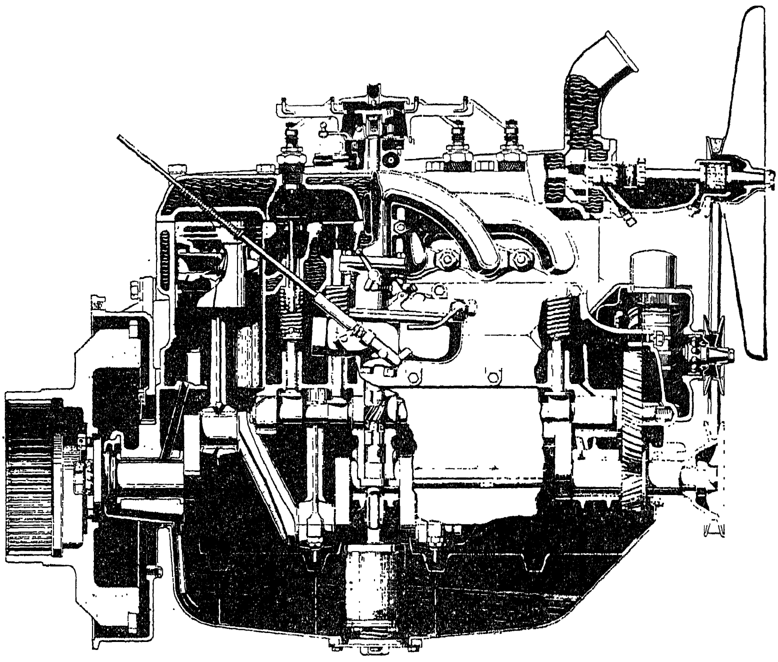


Fig. 5. Ford Model "A" Engine
Note form of rod and troughs provided for oil and rod dipper action.

shaft bearing it will be just a few seconds until a film of oil appears at the other end, having been carried through between the bearing and the shaft, spreading in a thin film and performing the duties of lubricating the bearing. In much the same way, oil finds its way in the connecting-rod bearing when it is once deposited upon a shaft and rod end.

In the case of the forced-feed system, the oil is forced to the main bearing through a tube or other line and, after lubricating the

main bearing, the excess oil finds its way into the inside of the crankshaft through the drilled holes. From the main bearings then, the oil flows through the crankshaft throw to the connecting-rod journal and out of it into the connecting-rod bearing. Excess oil from the connecting-rod bearing may be thrown off into the crank case, there to lubricate other moving parts.

Considering the two methods of oiling, the automechanic understands that there are certain requirements to be met when fitting a bearing with either of these two types. Since the amount of oil carried in the splash type bearing is considerably less than the amount forced in the forced-feed bearing, it stands to reason that there should be less clearance provided for the splash type than for the forced-feed type. As a matter of fact there may be quite a bit of clearance in the forced-feed type without any distracting connecting-rod knocks. This is not true of the splash type. If there is more than a certain minimum allowance, the connecting rod is certain to knock, as there will not be enough oil there to cushion the blows. The mechanic should keep these facts in mind when fitting up connecting-rod bearings. The following instructions are given with these facts in mind.

SERVICING CONNECTING RODS

What Happens When the Connecting Rods Fail. The cause of connecting-rod bearing failure, as a rule, is lack of lubrication. In some instances, however, rod bearings fail because of poor workmanship; and occasionally rod failure results from flaws in rod metal.

The lubrication system may fail because of lack of oil, poor grade of oil, diluted oil, or clogged or broken oil lines. The degree of failure will vary from a very slight failure all the way to complete loss of bearing material. When the latter happens, the bearing is said to have burned out. Burned bearings, such as those illustrated at *A* in Fig. 6, are not at all uncommon and are due to the failure of the lubrication system. These bearings have not been completely burned out, although they have been burned to a point where they are worthless. They are not fit to be reconditioned; and in every case of severe burning such as this, the bearing must be rebabbitted or the shell replaced. Where the burning is very slight, the burned portion may be scraped away, exposing new metal, and the bearing refitted. When a bearing heats up quickly and excessively, the

babbitt metal is melted and is thrown out of the connecting-rod end.

A mechanic, when inspecting a set of connecting rods or mains

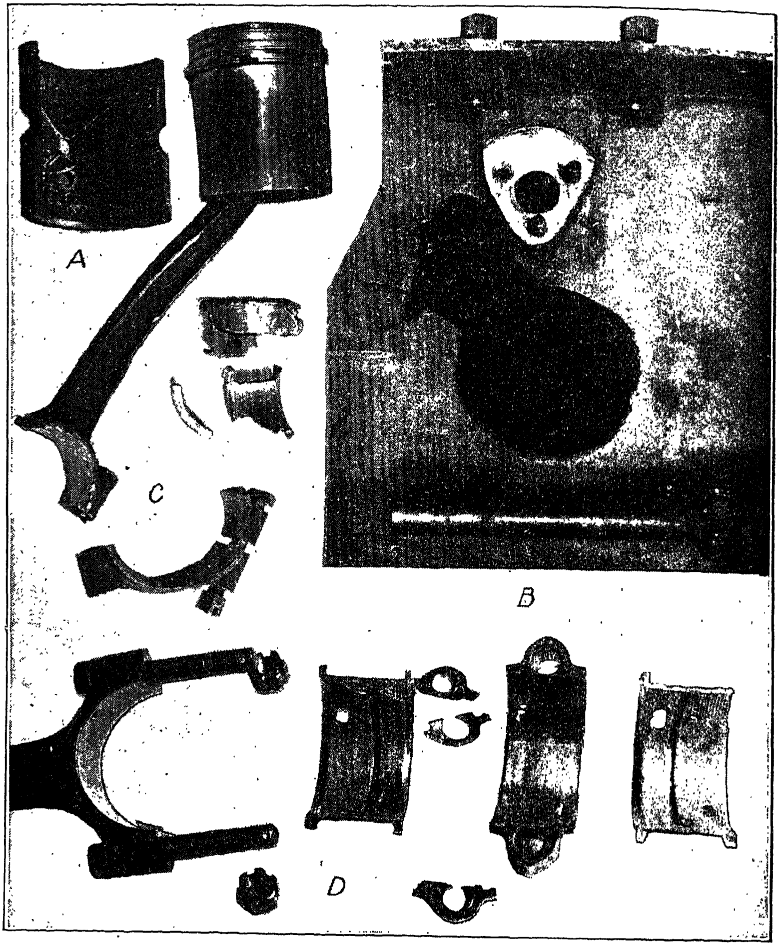


Fig. 6. *A*—Burned Connecting-Rod Bearing
B—Crank Case of an Engine Which Was Broken When Connecting Rod at *C* Let Go
D—Connecting-Rod Bearing Broken Because Engine Was Run with Rod Improperly Adjusted

for evidence of burned bearings, always looks in the bottom of the oil pan or in the oil trough to see whether there is any evidence of a babbitt deposit there. By running the finger along the bottom of

the pan or trough, a certain amount of sludge or dirt will be picked up. Rubbing this dirt between the fingers will expose bright particles of babbitt if the bearings have been overheated. In those cases where metal has melted and flowed from the bearing, of course there will be considerable quantities found in the trough. This simple expedient is often used in order to locate that bearing or those bearings which are at fault. Sometimes when only one rod is burned, this will locate the rod quickly.

Broken Connecting Rods. Bearings which have become out of adjustment will "pound" in a very lively fashion. If an engine is operated with a loose connecting rod, at a high rate of speed, the rod is very likely to be thrown from the crankshaft and serious damage may result. At *B* in Fig. 6 is shown a crankcase which had a hole broken into it when a connecting rod was thrown from the crankshaft. The connecting rod which was thrown is shown at *C*. Another rod which likewise suffered from bearing failure but which was not thrown from the crankshaft is shown at *D*. This particular damage was done owing to careless workmanship. The would-be mechanic, after adjusting the connecting rods, failed to insert the cotter keys to lock the connecting-rod bolt nuts in place. After one nut had backed off, the engine being speeded up, the rod cap was thrown off and the rod itself went through the side of the crankcase when the crankshaft throw came around and hit it.

Another instance of connecting-rod failure occurred when a cold engine had speeded up to a high rate of speed, with the car standing idle. There is a tremendous load placed on a connecting rod when an engine is turned over at a high rate of speed. This load is not due to the explosion of the engine but to the centrifugal force and the force of inertia. It must be remembered that the piston must be stopped and started some thousands of times each minute. If there is a little play in the bearing to start with, serious trouble is likely to result.

Adjusting Shimmed Connecting Rods. Not all connecting rods are provided with shims. Where shims are provided, the most popular form is what is termed laminated shims, such as illustrated in Fig. 7. These shims are made of thin strips of brass sweated together. As a rule the thinnest layer of lamination is approximately .001 inch. Successive layers may be of this same thickness or thicker.

Connecting-rod bearings wear so that the clearance between the rod and the crank pin becomes too great. If the repair man will remove the bearing cap, as illustrated in Fig. 8, he will find the shims remaining on the connecting-rod bolts. These shims should

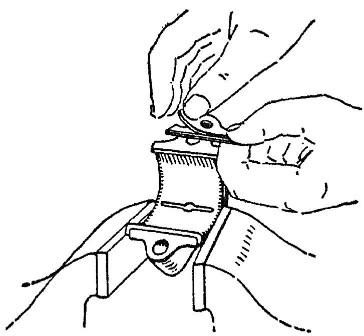


Fig. 7. Peeling Laminated Shims When Adjusting Connecting-Rod Bearings

be pulled off, one at a time, and a thin layer peeled off as suggested in Fig. 7, after which the shim is replaced in exactly the position it occupied originally. When both shims have been peeled, the cap is reinstalled and the connecting-rod bolts are drawn up tight. As a rule this work is done without removing the connecting rod from the engine, simply dropping the crankcase so as to have access to the connecting rods. Having removed a thin layer of shim and tight-

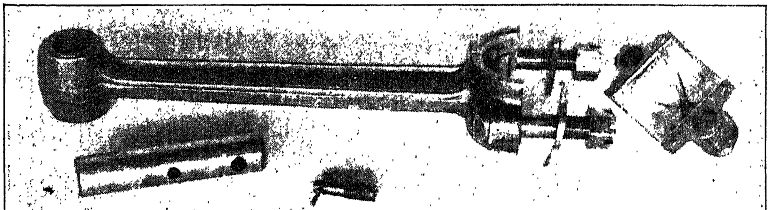


Fig. 8. Connecting-Rod Shims Must Be Maintained in Proper Position When Adjusting Bearings
Note those on the connecting-rod bolts.

ened the connecting rod, the helper is asked to turn over the engine. If a very slight drag is found on the crankshaft when it is turned over with the hand crank, the mechanic knows that this slight drag is due to the tightening up of the connecting rod being worked on.

If the helper notices no increased drag on the rod, the cap is removed again by the automechanic and another thin shim removed from each side. After this the cap is replaced and another test made.

The above method is followed until a slight drag is noticed on the crankshaft as the helper turns the engine over. If the last shims removed allow too much tension to come on the crank pin, the cap must be removed and a very thin shim replaced on each side.

Caution. Under no circumstances must the connecting-rod bolt nuts be backed off to allow the proper play in the connecting-rod bearing. The shims are placed in the bearing cap in order that the connecting-rod bolts may be turned up very tight, at the same time allowing just the slightest amount of clearance between the connecting-rod bearing and the crank pin. This is a point which is very difficult for the average beginner to master. In many cases the workmen have been known to back off the connecting-rod bolt nuts until just the right feel or drag was noticed on the crankshaft when turned over by hand. The cotter keys were then inserted in the connecting-rod bolts and the job assumed to be a satisfactory one. This is far from the truth and unless the proper shims are in position and the connecting-rod bolts locked as tight as the average speed wrench will permit, trouble of the nature of that shown in Fig. 6 is likely to develop within a very short time. The careful mechanic will always continue testing by removing or replacing shims until exactly the right tension is secured and the connecting-rod bolt nuts are turned home in a very snug fashion. That is what the owner of the car is paying for—skill of hand, mixed with a good bit of "gray matter."

After one connecting rod has been properly adjusted, the cotter keys are not installed, but the connecting-rod bolt nuts are backed about one turn on each nut. The mechanic then proceeds to adjust each of the rods until exactly the same drag is felt in each case. When the rods have been adjusted according to this plan, then the mechanic will proceed to draw up all of the connecting-rod bolt nuts and place in the cotter keys which prevent the castellated nuts from backing off.

The reason for doing the job in this manner is to enable the helper to sense exactly the same amount of pressure on each of the newly adjusted connecting rods. When all connecting rods have

been properly adjusted and tightened, the helper will find that he has what is termed a stiff engine and it will require a real effort on his part to turn over the crank by hand. Under no circumstances should the connecting rod be so tight that the helper cannot turn over the engine with the hand crank. To make them tighter is to invite trouble.

Shims. The use of bearing shims is very common, although many engines are put up without any shims. Where full-pressure lubricating systems are used, the shims are not so popular with the engine builder. Where the splash-fed lubrication system is used, the shims are more popular. However, shims may be found in either type of system. Where shims are used in the pressure-fed system, the edge of the shim next to the crank pin is usually tinned with

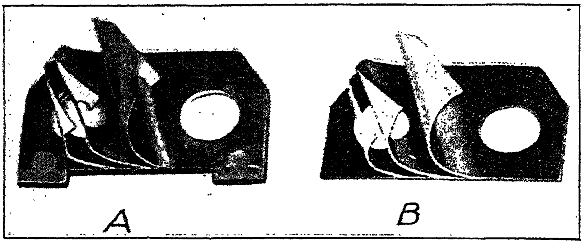


Fig. 9. *A*—Type of Laminated Shim Used in Most Connecting-Rod Bearings When Shims Are Used for Full Forced-Feed Oiling System
B—Type of Laminated Shim Used for Splash-Lubricated Connecting Rod or Main Engine Bearing

solder so that it may form part of the bearing. In Continental engine practice, where shims are used for the pressure-fed bearings, a small piece of babbitt is set on the outer edge of the shim, as shown at *A* in Fig. 9. This is to insure against the loss of oil past the end of the shim.

Sometimes the shims used are not of the laminated type but will be four or five in number for each connecting rod. These shims will vary in thickness from about .001 inch up to .015 inch. Sometimes it is not possible to remove just the right amount of shims by removing one of the thinner ones. In such circumstances it may be necessary to file the shim. This is a practice rather to be discouraged than encouraged as it is practically impossible to file a shim and reduce it equally at all points of its surface. If filing must be done

on a shim, place it on a board in which a large head nail or screw has been driven, then place the shim over this nail, or nails if more than one hole is in the shim, and proceed to dress down the shim by means of a fine cut mill file. It is better to use a piece of emery cloth and dress down the bearing cap than to attempt to file the shim.

Making Shims. It not infrequently happens that when filing down bearing caps or dressing them with emery cloth too much metal is removed. Under these circumstances it is absolutely necessary to install a thin shim to compensate for the metal which has been removed. Most garages carry in their stockrooms rolls of shim brass. This brass is provided in thicknesses varying from .001 inch up to .005 inch. When it is necessary to make a shim, the first thing to do is to lay out the shim on the shim stock, using an old shim or bearing cap for a pattern. The next step is to cut the holes for the connecting-rod bolt. There are several methods of doing this, but drilling is not satisfactory as a general rule. In an attempt to drill thin shim stock, it will be torn. The best method is to use a shim punch or a hollow sheet-metal punch which will remove the metal from the hole, leaving a clean edge. If no sheet-metal punch is available, grind the end of a proper sized bolt or cold-rolled steel perfectly square on the grinding wheel. Lay the shim stock on the end of a piece of hardwood or on a chunk of babbitt metal; set the improvised shim punch over the shim and strike it a good sharp blow. This will drive the metal from the hole into the end grain of the wood, leaving a clean cut hole. After the shim stock has been punched, then it may be trimmed to size with the tin snips. Finally, use a file to touch up the edges and remove any burrs from the newly prepared shim so that a true seat may be secured when it is placed in position in the rod.

Adjusting Pressure-Fed Bearings. When adjusting pressure-fed bearings, the same method is used as that for the splash type. The same sort of precaution should be taken with reference to all points, the one vital point of difference being that as close a fit is not required or recommended. As a matter of fact about .001 inch more clearance is recommended for this type of bearing than for the splash type. The experienced workman will be able to detect by the feel of the rod, when turning over a newly adjusted bearing, just how tight the fit is. Some mechanics like to use a piece of shim stock

.001 inch thick, placing a strip ½ inch wide in the connecting-rod cap before drawing it up for a test. If the helper can turn over the engine without much effort with this shim stock in position, the mechanic knows that the clearance is just about right. If the helper cannot turn the engine, he knows that the job is too tight. This is a scientific method of finding the clearances. The more experience a mechanic has on any make of engine, the more quickly he will recognize the proper fit on connecting-rod bearings.

Fitting Connecting-Rod Bearings. The first operation is to remove the connecting rods, which in some engines can be pulled from the bottom of the engine as shown in Fig. 10. There are several methods of fitting connecting-rod bearings which have come into use with the advent of the highly standardized engines in use. Precision methods in manufacturing put out an engine, the parts of which are exact duplicates within very close limits. It is possible to use precision methods in repairing these accurately built engines. However, the automechanic will find many times that there is nothing quite so good for the work as hand scraping bearings to fit.

When fitting connecting-rod bearings by scraping, it is absolutely necessary to have the crankshaft at hand, or a mandrel which is exactly the same size as the crankshaft, to which the bearing may be fitted as the work proceeds. Fig. 11 illustrates one method of mounting a mandrel in a vise so that the work of bearing fitting may be carried on with the best results. The crankshaft is not always out of the engine, however, and if the workman does not want to crawl in under the engine and out many times, he should provide himself with a mandrel, Fig. 11 at *C*, the exact diameter of crank pins.

Use of Bearing Blue. Whenever bearings are to be scraped to a fit or whenever the mechanic desires to test the fit of bearings, he makes use of what is termed bearing blue. This is an oil and blue mixture sold in small tubes for the special use of the mechanic. In order to get what the mechanic terms an impression the usual practice is to place a very small amount of the bearing blue on the end of the forefinger and then distribute it evenly over the mandrel or crank pin, as the case may be. The connecting rod is then slipped into position and tightened on the mandrel. By turning the connecting rod forth and back around the crank pin, the high points

on the bearing will receive an impression from the blue on the crankshaft or mandrel, with the result that an impression similar to that shown at *B* in Fig. 11 is secured. It will be noted that the impression is not evenly distributed and there are certain high points. It is desired to have the impression evenly distributed as shown at *D*. To this end it is necessary to use the bearing scraper to reduce the

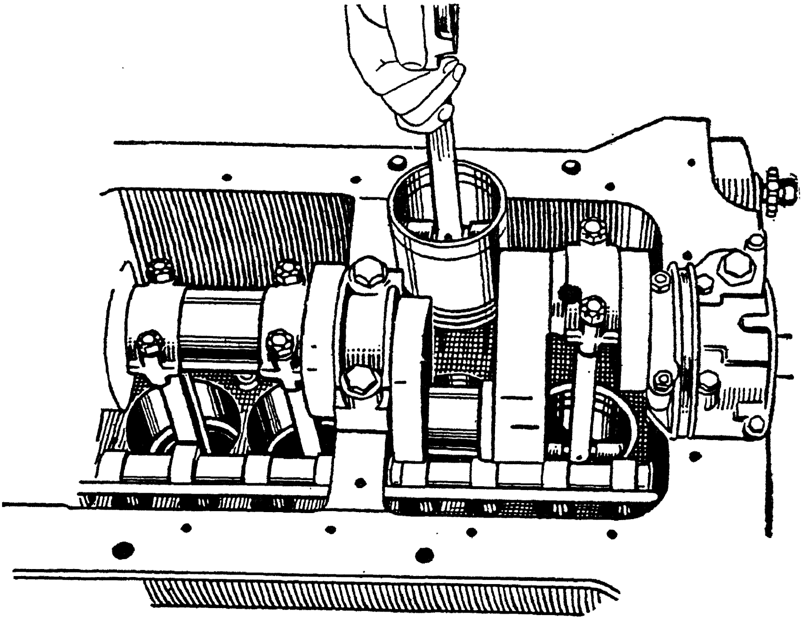


Fig. 10. Pulling Piston and Rod Assembly
Courtesy of Studebaker Corporation

high points which appear at *B* so that more surface of the bearing may be brought into contact with the crank pin.

Scraping the Bearings. The first thing to do when starting the bearing scraping work is to clamp the bearing cap or the connecting rod in the vise, as suggested at *A* in Fig. 11, being very careful not to grasp the cap in such fashion that the ends of the soft bearing metal are damaged. Not infrequently the inexperienced mechanic will use the vise to hold the bearing cap in such a manner that considerable damage is done to the bearing metal. It must not be permitted. To do so invites disaster and is the sign of a careless workman.

Having the cap properly secured in the vise, use the bearing scraper to cut off a thin film of metal from the entire surface of the bearing. This is recommended for the simple reason that a bearing which has been in use over a long period of time has accumulated a certain amount of grit and the exposed metal is very hard. Just enough metal should be removed in order to get through this initial film and down to the softer and cleaner metal underneath. Having

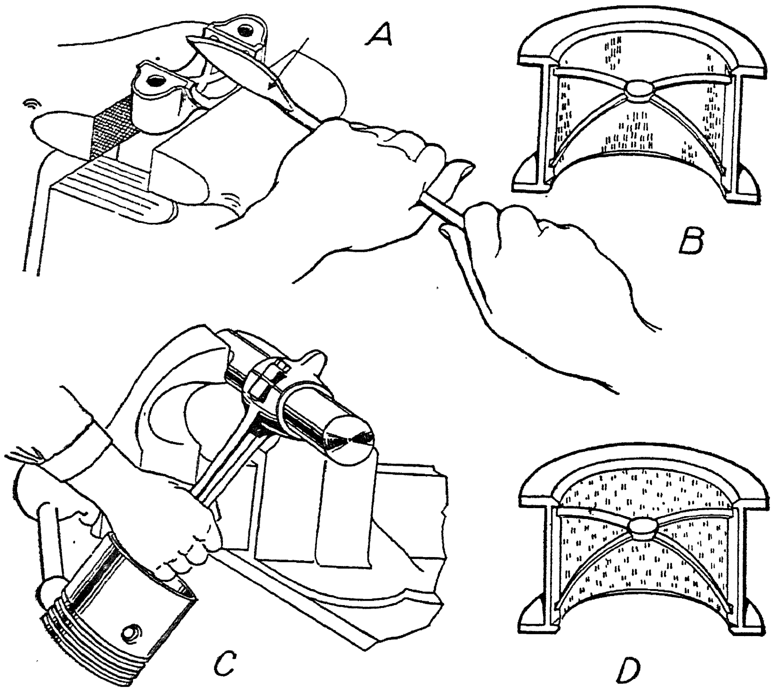


Fig. 11. *A*—Method of Scraping Rod-Bearing Cap
B—Impression Such as Is Secured When Bearing Does Not Fit Shaft Properly
C—Method of Getting an Impression over a Mandrel
D—Impression Which Is Secured When Bearing Is Properly Fitted

removed this first cut, the impression is then made; after which a scraper is used to reduce those high points which appear on the surface of the metal indicated at *B* in Fig. 11.

After scraping off the high points of the first impression, another impression is made and again the high points are scraped off. This work proceeds until a perfect bearing is secured, as illustrated at *D* in Fig. 11. Considerable experience is required to develop skill in

fitting bearings. The first bearing may be just as perfect as the last one, although much more time is required in learning the process than in doing it; but after having acquired skill in fitting bearings, speed follows.

The beginner must be very careful not to remove too much metal at the sides of the bearings, that is, close to the split of the bearing. If too much metal is removed at this point, a great deal of metal will have to be removed at the top and bottom of the bear-

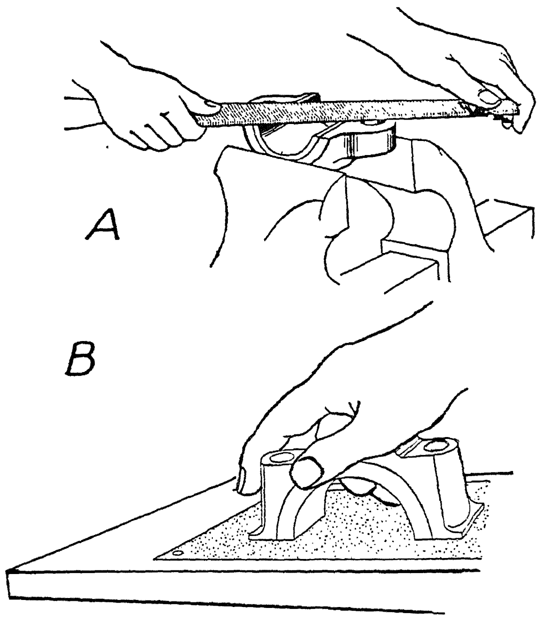


Fig. 12. *A*—Draw Filing a Connecting-Rod Cap or Main Bearing Cap
B—Method of Grinding Connecting Rod or Main Bearing Cap with Emery Cloth

ing in order to compensate. The bearing moves in one direction only and for that reason not much take-up is possible on the sides next to the split.

Filing or Grinding Bearing Caps. As the scraping proceeds, it will be found that unless shims are removed or the bearing cap reduced by filing or grinding that play will exist between the crank pin and the bearing. In fact, after about the first impression and the first scraping, it will be found impossible to secure another

impression of real value. For this reason, it is necessary to remove shims or file them. If no shims are used, the cap itself must be reduced by filing, as shown at *A* in Fig. 12, or by grinding on a sheet of emery cloth, as shown at *B*. This is a piece of work which will have to proceed most carefully, considerable skill being required. For instance, unless considerable skill and patience are used, the result pictured in Fig. 13 or Fig. 14 will be apparent when an attempt is made to fit the rod cap in position. Fig. 13 shows the result of rocking the file as it is run over the cap and the rod. Fig. 14 shows the result of too much filing toward the center of the cap. It would be impossible to secure proper lubrication in any case where the

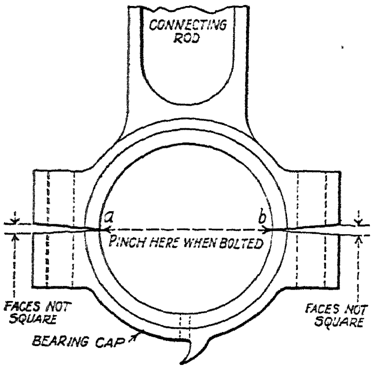


Fig. 13. Faces of Connecting Rod and Cap Filed with Convex Surfaces

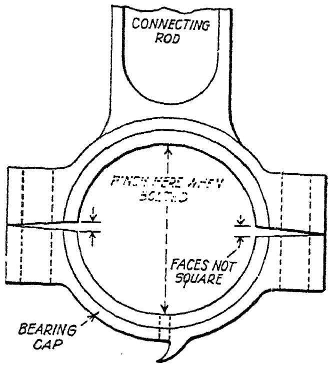


Fig. 14. Faces of Connecting Rod and Cap Filed with Concave Surfaces

parts did not fit together perfectly. This is especially true with reference to the full forced feed, where a condition such as that shown in Fig. 14 would allow so much oil to escape that the connecting rod would be burned out. The condition shown in Fig. 13 would result in all the pressure coming on the soft metal of the bearing with the result that it would quickly fail.

When using a file as shown at *A* in Fig. 12, select a fine cut file and use care to draw-file the cap so as to touch and cut all of the surface evenly and equally. Keep the file clean and throw a pressure on to the center of it by giving the ends a twist when proceeding with the cut. The method used at *B* in Fig. 12 is usually the better method of the two, especially in the hands of one not accustomed to the use of a file. While the chances of securing a good job are

much better by this method, exceeding care must be used to see that the cap is turned from end to end every little while and that the grinding proceeds with a rotating motion as well as a forth and back motion, the idea being that the more the cap is moved about the better the chances are of equalizing the cut. Under no circumstances use a side pressure when doing this work.

Testing Fit of a Scraped Connecting Rod. After the work of scraping has proceeded to a point where the job is practically finished, then the mechanic will give consideration to the exact fit of the connecting-rod bearings on the crankshaft. Not too much drag must be in evidence. In the case of the full forced feed, the best mechanics recommend that the fit be such that if the connecting rod and piston are pulled up, as indicated at *C* in Fig. 11, to a horizontal position, the weight of the piston and rod will be sufficient to carry the rod downward. The use of the shim method of checking clearance is recommended where an exact fit is desired.

While the above is recommended for a force-fed bearing, a bit tighter fit may be used for the splash-fed bearing. In this case, fit the bearings until a slight pull is needed to pull the connecting rod and piston downward in addition to the weight of the piston and the rod itself.

Caution. Keep an exceedingly close lookout for false bearings when fitting connecting-rod bearings. A false bearing may be secured if the edges of the bearing are not properly scraped away so as to fit them to the fillet of the crank pin and shaft. For instance if an arbor is used, as suggested at *C* in Fig. 11, the fillet would not be taken into consideration; and when the rod was assembled on the crank pin, it might be felt that a good fit was secured when as a matter of fact the bearing would be altogether on the slight portion which struck the fillet of the pin.

Another point which might give a false impression and which has been known to fool many mechanics, is having no end clearance on the bearing. For instance if a set of new bearings is being fitted to a crankshaft, it may be necessary to provide end clearance. The amount of end clearance to be provided should be approximately .002 inch to .004 inch. If no end clearance existed, then there would be a feeling of drag to the rod, although the rod might have as much as .005 inch or .010 inch clearance on the crank pin. The careful

mechanic will give considerable thought to the side or end clearance of the bearing and to the way the fillet fits so as to prevent any possibility of a false bearing. The load comes on the main surface of the bearing and these are ample to carry the load. If a very small surface were in contact with the shaft, such as might be the case with a poorly fitted bearing where only the fillet touches the shaft, then the engine would quickly make trouble when put into use and the work would need to be done over.

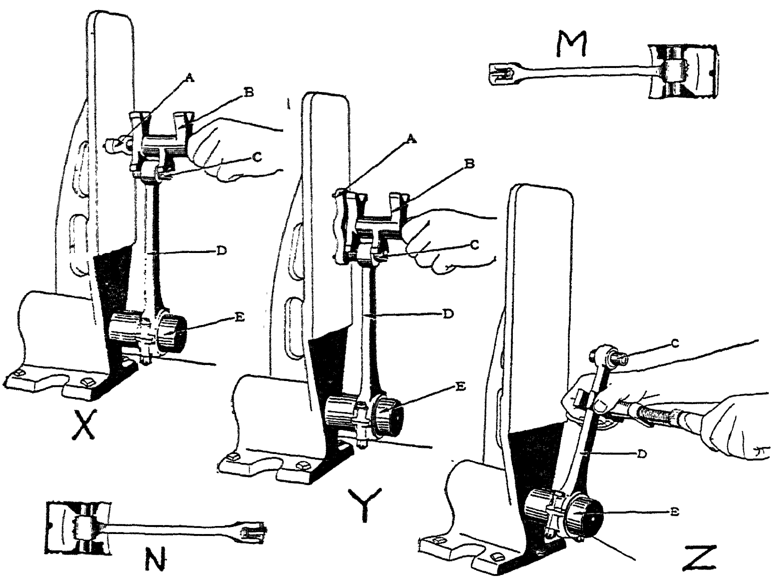


Fig. 15. *X*—Checking Rod for Twist
Y—Checking Connecting Rod for Bend
Z—Using Large Monkey Wrench to Twist Rod into Alignment
N—Connecting Rod Properly Aligned with Reference to Piston-Pin Bosses
M—An Out-of-Alignment Connecting Rod Will Strike the Piston-Pin Bosses

Aligning Connecting Rods. Connecting-rod aligning jigs are used in all shops. These are supplied in a variety of forms. The fixture shown at *X*, *Y*, and *Z* in Fig. 15 consists of an arbor *E* which is at right angles with the surface of the plate. The connecting rod to be tested is fitted on to the arbor. Jigs designed to be universal have varying sized arbors or sleeves which may be fitted over the arbor, so that any standard rods may be tested with one fixture. In Fig. 15, *A* points to a little device which is used to show twist

of a connecting rod or bend when used in connection with the other device *B*, which is provided with V blocks to rest on the piston pin *C*. Having the rod properly fitted to the arbor, this fixture *B* is then placed on the piston pin *C* and the part *A* is placed in the position indicated at *X*. There are two small dowel pins set into the face of the part marked *A*. When placed in the position shown at *X*, these two dowel pins must strike the surface of the fixture evenly. If they do not do so, the rod is twisted and a heavy monkey wrench is used to grasp the rod as shown at *Z*. Twist it until a test as shown at *X* will show both of the dowel pins striking the surface at the same time.

Connecting rods are subject to bending sidewise. They may even be offset sidewise. The condition shown in the section of a piston and connecting rod at *M* is that of a connecting rod which has been bent or offset until it strikes one of the piston-pin bosses. This condition is certain to cause rapid wear and may be the source of a very troublesome knock. A properly aligned connecting rod should have clearance between each of the piston-pin bosses, as indicated at *N*.

In testing for connecting-rod side bend or offset, the jig is used as shown at *Y* in Fig. 15 where the part of the fixture *A* has been turned at right angles to the former position shown at *A* in *X*. In this position the two dowels should engage the surface of the jig at exactly the same time, making certain of course that the part *B* is held in firm contact with the piston pin *C*. If the connecting rod is bent, the direction of bend will be indicated by whether the bottom or top pin strikes the surface first. In case the connecting rod is bent, it may be straightened by means of the monkey wrench, as shown at *Z*, after which the check-up shown at *Y* is repeated; and then if this shows O.K., the check-up shown at *X* is repeated to make certain that no twist has been placed in the rod while straightening it.

Connecting-Rod Offset. Some connecting rods are provided with an offset. This may be a very slight amount or it may be quite noticeable. Normal offset means that the connecting-rod shank is not in exact center with reference to the connecting-rod bearing in the big end. This may be done in order to accommodate the crank-shaft bearing to the cylinder block. It is specially likely to be the case where fewer main bearings are used than there are cylinders in

the engine. A casual glance will show the offset at once if such has been built into the rod.

Abnormal offset is that which has been induced into the rod for some reason or other—mishandling or undue engine strain. In order to check up a rod to find out whether or not an offset exists which would give a condition similar to that shown at *M* in Fig. 15, the connecting rod should be mounted on the mandrel with the pin locked in position in the exact center. Place the end of the piston pin in contact with the surface of the testing jig. With a rule, carefully measure the distance from the connecting rod to the back of the fixture at the point where it is fastened on to the mandrel *E*. Make a notation of this and then reverse the rod on the mandrel and recheck. If there is an offset, this check-up will show it.

In order to remove offset, the rod must be bent at a point just above the big end and then it must be rebent at a point just below the piston pin. After this has been done, the check-up shown at *X* and *Y* in Fig. 15 must be repeated in order to see that there is no twist or bend left in the rod.

Fitting Die-Cast Bearings to the Rods. The usual practice with reference to connecting-rod bearings is to secure new ones from the dealer. These are of two types—the die-cast bearings and the poured bearings. The die-cast bearings are bronze or steel backs with a thin coating of high-grade babbitt metal and are known as replaceable bearings. In the poured bearings, the babbitt is poured into the rod itself.

At *D* in Fig. 11 is shown a die-cast bearing. At one time it was the practice to use only babbitt metal in casting these, but later practice showed the wisdom of using a bronze backing, since the bronze back is much stronger and has equal heat conducting properties. At *D* in Fig. 6, the die-cast bearings have been removed from the connecting rod and the connecting-rod cap. Each of these bearing shells is held in the upper half and lower half of the rod bearing by means of two brass screws, the holes for which are shown in the bearing shell as well as in the rod halves.

Rod bearings of this type which have become badly worn are simply removed by removing these brass screws, which are discarded along with the bearings removed. All traces of oil are wiped from the surface of the rod. Any slight imperfections, such as burrs,

which may have been raised about the rod halves, are removed with a file or emery cloth. The new bearings are inspected carefully to see that they have no burrs or that there is no dirt lodged on the surface which is to come into contact with the rod halves. When these parts are thoroughly clean, fit them together by slipping the new bearings into the rod halves and running home the screws. If there is any question about the fit of the parts, use a bit of bearing blue to get an impression. As a rule, however, this will not be necessary. Tighten the screws as much as seems best and then place the connecting rod on the mandrel or on the crank pin, running in the connecting rod bolts and drawing the job up tight. This will cause the parts to seat in good position, after which the job is removed from the mandrel and the brass screws further tightened. The next thing to do is to rivet over the projecting ends of the little brass screws to prevent them backing out. If this is not possible, the next best thing is to use a small punch, driving a bit of the babbitt metal into each side of the screw slot in order to prevent the screw backing out when placed in service. After the die-cast shells have been installed in connecting rod, the bearing is fitted to the crankshaft.

Rebabbitting Connecting-Rod Bearings. There are several methods of applying the babbitt metal directly to the rod metal. The oldest method is to use a jig and pour the metal in the big end of the rod. A later development and one in great favor with car manufacturers is what is known as spinning the metal in the big end of the connecting rod. Where this process is used, the connecting rod is mounted on a machine which resembles a screw-cutting lathe. The rod is placed on the face plate and started rotating. The inner surfaces of the big end of the rod have been treated with flux so as to tin them to have them ready to receive the babbitt metal. The babbitt metal is run into the big end of the rod while the machine is rotated at a rapid rate. In this way a centrifugal motion is imparted to the babbitt metal which is flowing into the center of the big end of the rod. This centrifugal motion gives a force which throws the metal to the inner surfaces of the big end of the rod, leaving it deposited, as it cools, in a layer of suitable thickness for the bearing being constructed. As a rule, thin shims have been installed in the connecting rod and these serve as a parting line for the two halves of the rod bearing.

This type of work, of course, is beyond the ordinary garage. The usual practice where spun rod bearings are used is to have the rods returned to the factory for rebabbitting or have them returned to the dealer, who has an exchange arrangement with the factory, a certain allowance being made for the rods returned and the difference being paid by the garage man. This is also true with reference to many cast-in bearings. In some cases the exchange price is a

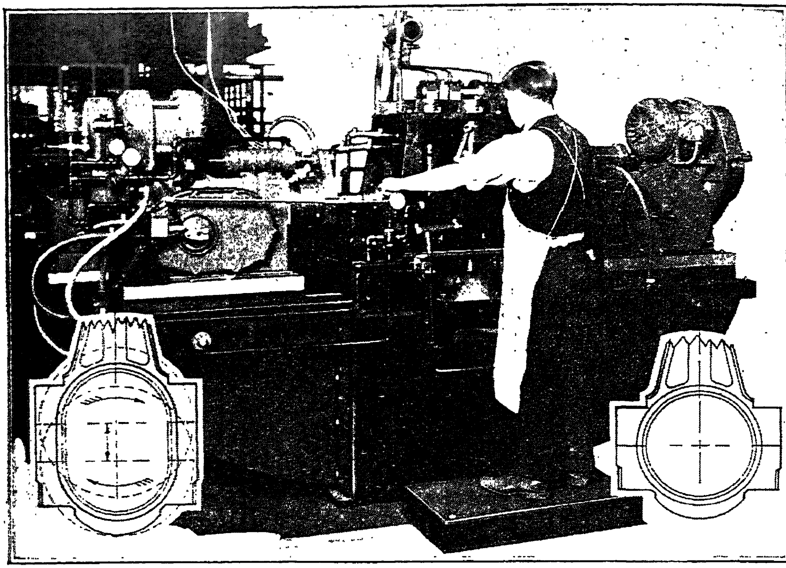


Fig. 16. Machine Designed to Face and Bevel the Elliptical Main Bearing Hole of an Oldsmobile Connecting Rod. Diagram at Lower Left, Slightly Exaggerated, Shows Path of Circular Cutter in the Ellipse. Diagram at Right Shows Connecting Rod Bearing After It Has Been Cut in Two Parts, Now Forming a Perfect Circle

rather nominal figure, being as low as $1.00. In the larger cities automotive jobbers are usually equipped for rebabbitting rods in the service stations.

Machining Connecting Rod Big End Bearing. The latest method of machining the big end bearings is shown in Fig. 16. The hole is machined and then sufficient metal is cut out to form a true circular bearing.

Machining Connecting Rod Small End. Fig. 17 shows equipment used to bore the hole in the small end of the connecting rod. It consists of a jig and boring bar on an engine lathe bed.

Balancing Connecting Rods. Fig. 18 illustrates a factory set-up for balancing connecting rods. All reciprocating parts and rotating parts should be accurately balanced against each other. For instance, the difference of one ounce in the weights of the several

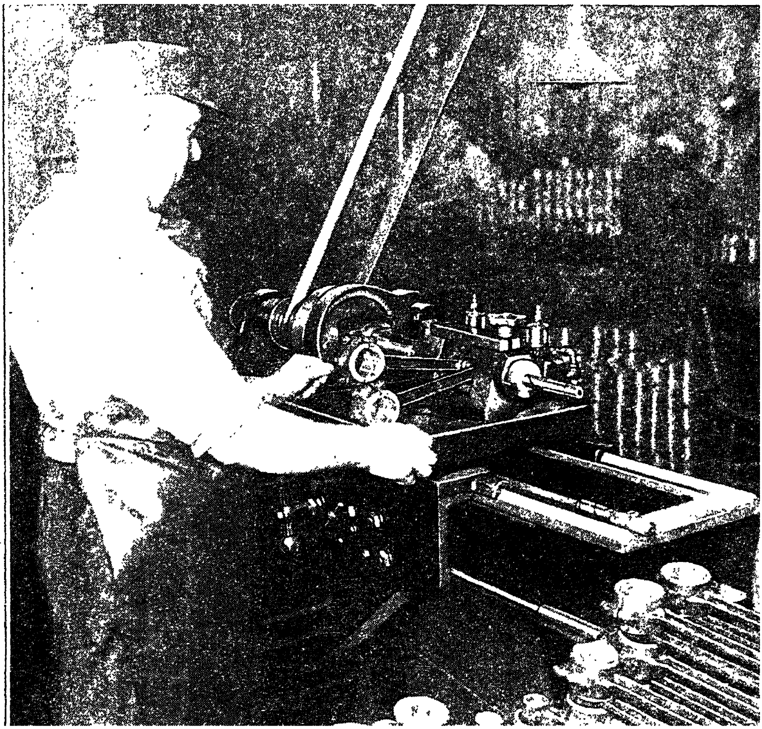


Fig. 17. Boring Out Connecting Rods (Small End) for Piston Pins

connecting rods in use in an engine will result in considerable vibration and power loss.

The amount of power lost in an engine assembly, with the crankshaft and reciprocating parts out of balance, is almost beyond belief. When an engine is being rebuilt for speed, all rotating parts and reciprocating parts are balanced most carefully. This is a universal practice with racing-car builders.

When replacing a broken rod or when rebuilding an engine, it pays to weigh the rods and compare them with each other, balancing

them as the need is apparent. It is not enough to have all the rods in an engine balanced according to the total weight of the rod. That is essential but it is also essential to have all of the big ends balance each other and all the small ends balance each other. An easy way to do this where all sizes and lengths of rods are handled is to use a short mandrel for the big end of the rod and after fitting the

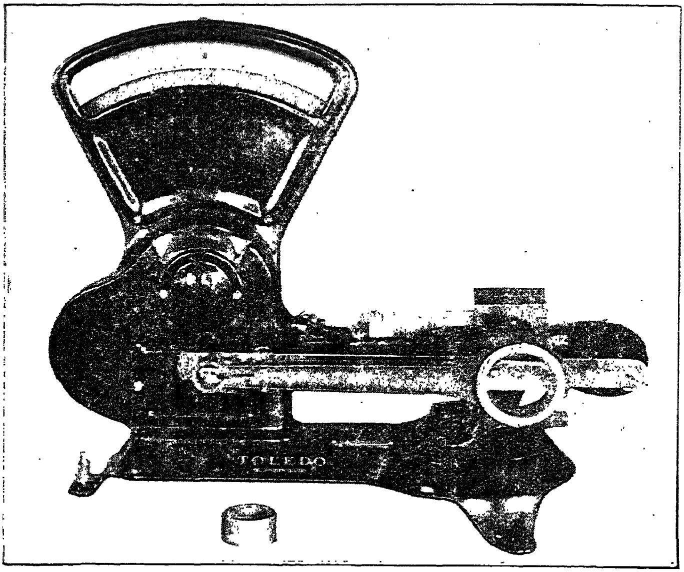


Fig. 18. Factory Set-Up for Balancing Connecting Rods
Courtesy of Toledo Scale Company

mandrel in the rod end lay it on knife edges which are just on a level with the scale platform. This enables the workman to balance all the small ends. Have the piston pins in place while doing this work. Next, proceed to balance the large ends by weighing them against each other, without the mandrel, but with the piston pin resting on the knife edges, level with the scale platform.

Cadmium-Silver Bearings. Owing to the high engine speed maintained over long periods of time in passenger car engines, more and more thought has been given to providing bearing materials which will stand up under the excessive loads. The 1935 Pontiac engine introduced the use of cadmium-silver as bearing material. One of the chief difficulties encountered with babbitt bearings is the

fact that under high temperatures such as are attained in the crank case, the babbitt metal becomes weakened and is inclined to break or fall away and in extreme cases to be melted. The melting point of babbitt is approximately 450 degrees while that of the new alloy cadmium-silver is approximately 610 degrees. The physical properties of the cadmium-silver, when compared with those of the babbitt, show that the cadmium-silver is approximately three times as strong.

The temperature attained by bearings in crank cases when operated at high speeds is around 300 degrees. It will be seen that if it exceeds this point very greatly there is extreme danger of burning out babbitt-lined bearings. On the other hand, the difference between the operating temperature of 300 degrees and that of the cadmium-silver bearing, which is subject to melting at approximately 600 degrees, is more marked. The same thing can be said for the copper-lead bearings which are being used in certain passenger cars.

Fitting Pontiac Connecting Rod Bearing. The Pontiac practice of fitting connecting rod bearings is by use of the thin type of replaceable steel backed bearing metal lined bearing shells. These bearings are manufactured to very high standards of exactness and no attempt should be made to recondition the bearing in the shop. Instead, undersized bearings should be installed.

The 1937 Pontiac connecting rod bearing cap with the bearing laid in position is shown in Fig. 19. Note that two small tangs are stamped into the bearing to hold it in position in the slot machined in the bearing cap metal. When fitting the connecting rod bearings, first remove the connecting rcd and then use the micrometer to measure the shaft, and inspect it to see whether it is scored. If it is scored or if any of the crankpins measure more than .001-inch taper or out of round, the crankshaft should be replaced.

When fitting the connecting rod bearings, .0015-inch brass shim should be used. This shim should be ½ inch wide and ⅞ inch long and should be laid into the bearing cap as shown in Fig. 19. Holding the shim in this position, slip the cap up cnto the bolt and lock it tight against the crankpin. Test the connecting rod by hand to see whether it is possible to move it endwise. If it is necessary to use a hammer and give the rod a light tap to move it, the fit is satisfactory. If the connecting rod bearing is loose on the crankpin with the .0015 shim in place and bolts locked tight, then the

bearing should be replaced with a .001-inch undersize bearing. When the job is finally complete, it should require a light tap of the hammer to move the bearing endwise on the pin.

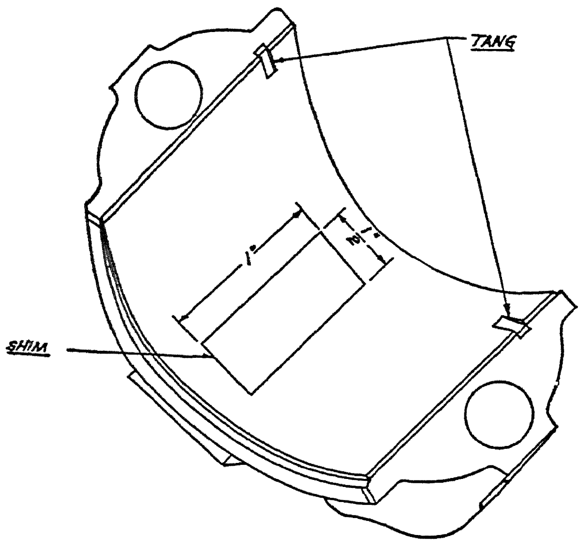


Fig. 19. Pontiac (1937) Connecting Rod Bearing Cap with Bearing in Position
Courtesy of Pontiac Motor Company

When installing the connecting rod bearing cap on the six-cylinder 1937 Pontiac, it is necessary to remember that the tangs on the cap shown in Fig. 19 should be on the opposite end of the crankpin from the tangs on the connecting rod.

CRANKSHAFTS—MAIN BEARINGS—FLYWHEELS

DESIGN AND FUNCTION

The crankshaft might be termed the backbone of the engine because it stands all the strain and stress of the power developed. The purpose of the crankshaft is to change the reciprocating movement of the piston and connecting rod into rotary motion and it is the first part through which the power developed above the piston is transmitted in the automobile.

The engineer who is designing automobiles today is directing his effort toward the development of a smoother and more flexible running engine, and the design of the crankshaft has a great deal to do in regard to it. Perfect balance of the crankshaft is absolutely necessary where vibration is to be eliminated and smooth operation obtained. Every piece of revolving machinery has its critical speed at which a vibration is set up in the revolving mass. This critical speed vibration will start other parts vibrating which are close to it.

So in the automobile, the crankshaft has its critical speed vibration. Where close attention is not paid to the balance of the crankshaft, it will be found that at this critical speed the whole car will vibrate. Sometimes the shaft is so designed that the vibrating speed is not within the speed range of the engine and consequently no vibration is felt.

Crankshaft Balance. There are three distinct types of balance that the engineer has to take into consideration when he designs the crankshaft for an engine, especially in the high-speed class—static, dynamic, and deflecting.

Static Balance. Static balance is the state of balance when the shaft is at rest. When the crankshaft is made so that it will stay in any position in which it may be placed, without moving, it is said to be in perfect balance. After the crankshaft has been machined, the first test for balance is the static test, Fig. 1. A pair of knife edges are made perfectly level in every way and the shaft is

placed on these edges. If the shaft is in balance, it will not move or revolve. If it moves, the side that is heaviest must be made lighter until the balance is obtained. The heaviest side will, of course, be the side that drops to the bottom. The throws of the crankshaft should balance each other.

Dynamic Balance. The dynamic balance requires a special machine for the test, Fig. 2. The test is made while the shaft is revolving at different speeds and special indicators show exactly where and how much the shaft is out of balance. The parts that are out of balance are dressed down until there is no vibration. With the testing machine, Fig. 2, the static and dynamic test can be made at the same time. The shaft to be tested is placed in the machine and rotated above its critical speed. The drive is released

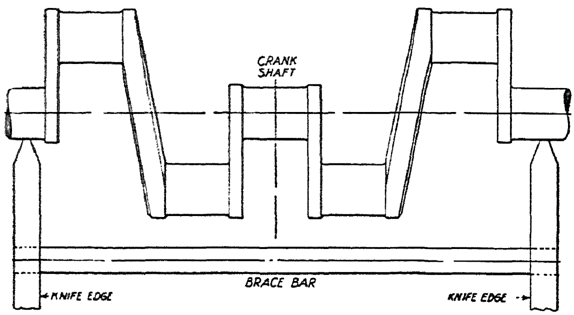


Fig. 1. Static Crankshaft Balance

and an indicator reading is set on a calculating rule which shows how much the shaft is actually out of balance. A weight is placed according to the reading of the rule to offset the "out of balance" factor and the shaft is tried again. An indicator shows exactly where metal should be removed to balance up the shaft.

Deflecting Balance. Deflecting or bending balance is the ability of the shaft to withstand the continual twisting and distortion caused by the strain of taking the drive. It is dependent upon good dynamic balance. It does not matter if the shaft shows good dynamic balance at low speeds, there will be bending or deflection of the shaft if the dynamic balance is poor at high speeds. The strength of the shaft will govern this and therefore the design and calculations of the stress that the shaft will stand in operation are important.

In a shaft where counterbalance weights are used and they are removed for any reason, the shaft should be tried for both static

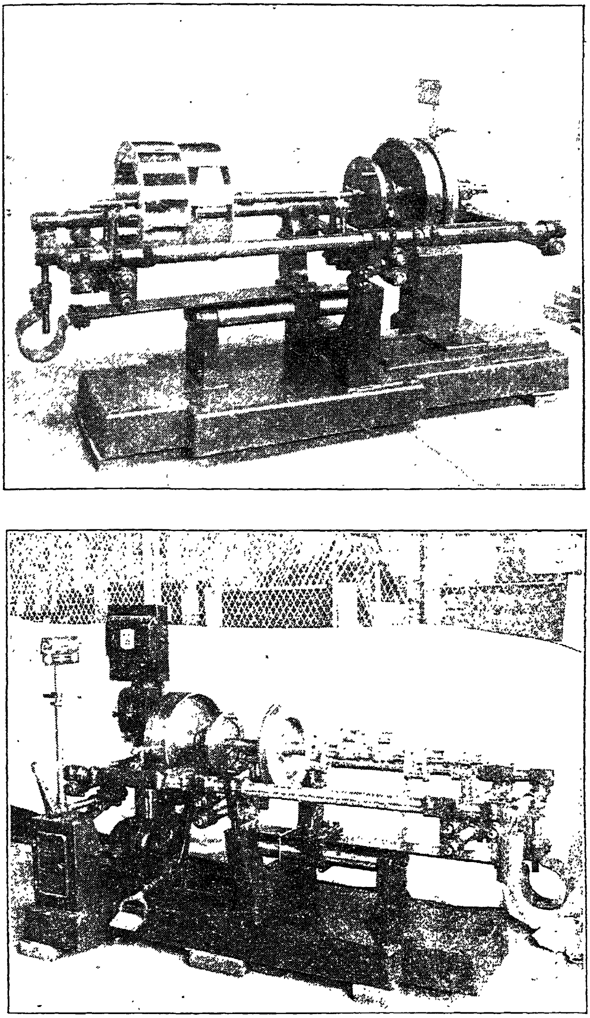


Fig. 2. Dynamic Crankshaft Balance Machine with Crankshaft and Flywheel Assembly in Position
Courtesy of Gisholt Machine Company, Madison, Wisconsin

and dynamic balance before being put back into service. Where balance weights are installed on a crankshaft with the idea of cut-

ting down the vibration, it will often be found that the trouble is worse instead of better and therefore the balance of the shaft should be tested before putting the shaft into service.

Crankshaft Material. In most cases crankshafts are made from an alloy of steel and nickel. This gives a very tough as well as strong shaft. It will be remembered that the work of the crankshaft is strenuous. While rotating at tremendous speeds, it must receive hundreds of power impulses each minute and deliver these through to the flywheel and clutch.

Most crankshafts are not so hard but what they may be machined in the lathe or by means of a hand tool. In some cases the file is resorted to in order to remove ridges or scratches on the crank-

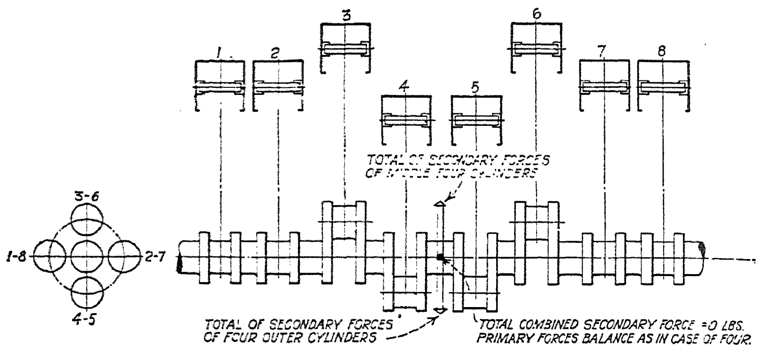


Fig. 3. A 2-4-2 Shaft for an Eight-in-Line Engine

shaft journals or crank pins. There are a few shafts made which are casehardened, and these may not be reconditioned by ordinary methods but need to be sent to the specialist where they are ground if it is necessary to recondition them. The casehardening should not be penetrated in the grinding process.

Variation of Crankshaft Design. Since the advent of four-cylinder engines, many years ago, crankshaft design has followed certain definite lines. The crankshaft for the four-cylinder engine, as a rule, has three or five main bearings. Formerly two main bearings only were used. In all cases it is necessary to have as many throws to the crankshaft as there are cylinders. The only exception to this being the six-cylinder four-bearing engines which sometimes have two cylinders on the center throw. A shaft design

which will accommodate the pistons and rods of a four-cylinder engine will also accommodate those of a V-type eight-cylinder engine. Usually the size is changed, the shaft being made heavier; but the point is that the inherent characteristics of design are the same for a four-cylinder or an eight-cylinder V type.

In the eight-cylinder-in-line engines, the usual practice is to have the 4-4 shaft or the 2-4-2 shaft, Fig. 3. In the first case we have

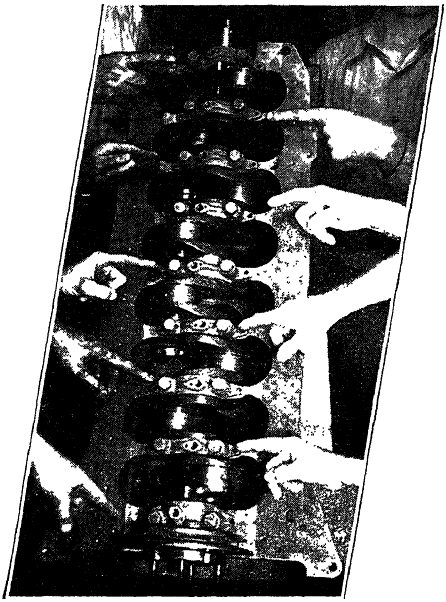


Fig. 4. Nash Nine Main Bearing Crank-shaft for 8-Cylinder Engine
Courtesy of Nash Motors

two four-cylinder shafts set end to end, one advanced ninety degrees over the other. The 2-4-2 shaft has the same effect as the four-cylinder shaft in the center and another four-cylinder shaft cut through the center and half of it set at each end of the four-cylinder shaft. In this construction the first pair of cylinders have throws advanced ninety degrees over the center portion of the shaft and the last two throws are likewise advanced.

Shafts for six-cylinder engines may have three, four, or seven main bearings. Shafts for twelve-cylinder V-type engines have the same general characteristics as shafts for the six-cylinder engines.

Counterbalanced Shafts. All crankshafts are balanced statically and dynamically. In order to offset the strains induced by the explosions of the fuel charges and the reciprocating force developed by the pistons and connecting-rod assemblies, many manufacturers have resorted to the practice of counterbalancing the crankshafts. One of the outstanding jobs so handled is the Hudson Super Six. Fig. 4 illustrates a counterbalanced crankshaft. In some cases the counterbalances are forged integral with the shaft, as shown in this

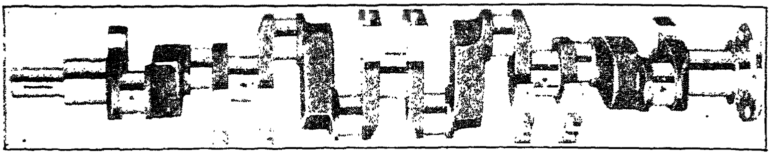


Fig. 5. Five-Bearing Eight-in-Line Crankshaft with "Bolted-on" Counterbalance

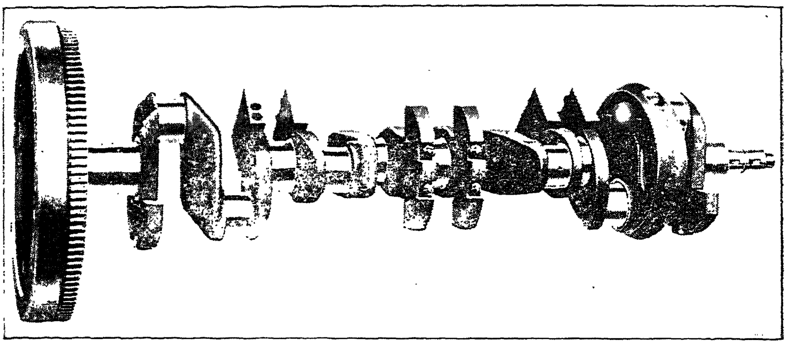


Fig. 6. Crankshaft Assembly with Counter Weights, Balancer, and Flywheel
Courtesy of Buick Motor Company

figure. In other instances, as illustrated in Fig. 5, the counterbalances are bolted to the throws or cheeks of the crankshafts. When counterbalances are used, it is possible to decrease the weight of the flywheel.

Crankshaft Torsional Balancer. A number of years ago it was discovered that owing to the twist of the crankshaft under load there was a decided tendency for it to set up vibration in the engine. It was further discovered that it was possible to place a torsional balancer on the crankshaft which would eliminate this torsional vi-

bration. These have been made in a number of forms and applied in a number of different ways. Fig. 6 shows the Buick torsional balancer, which is designed to prevent crankshaft vibration finding its way into the engine and from there being transmitted into the car body. This torsional balancer is assembled on a throw of the crankshaft and is secured in position by means of clamps and is under spring pressure. The inertia forces of the balancer or dampener are so

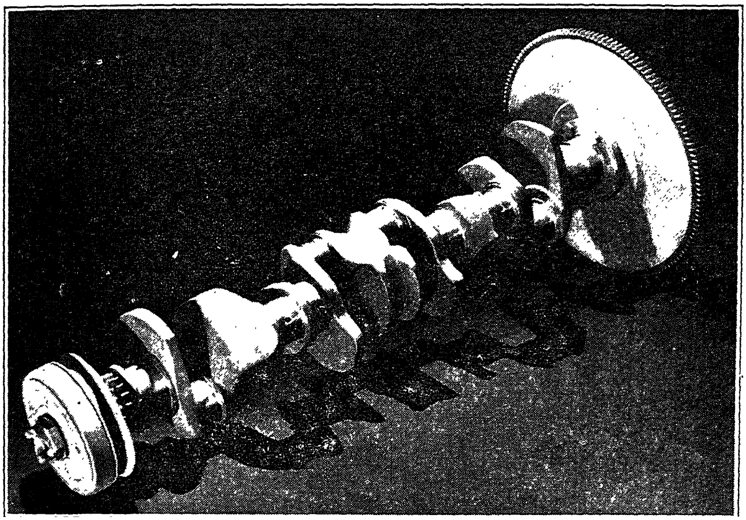


Fig. 7. Oldsmobile Six (1937) Crankshaft, Flywheel and Vibration Dampener
Courtesy of Olds Motor Works

calculated that as the twist comes on to the shaft and is then released, the tendency to vibrate is offset.

Front-End Crankshaft Vibration Dampener. Another device of many years standing is the vibration dampener applied to the front end of the crankshaft outside the crank case. These devices have taken a number of forms, the original ones being in the form of a light flywheel, which gave a two-flywheel job. Later designs resulted in applications a bit different. Most of these have provision for the application of the effects of inertia in response to the torsional vibration. Fig. 7 shows an application of this kind.

A departure in crankshaft design is found in the Cadillac crankshaft which is now of the counterbalanced type, Fig. 8. Here again

the designer has tried to prevent all possible vibration and it will be seen that the shaft is different in regard to the position of the crank throws, so that the weight of the moving pistons is balanced. A comparison between the old shaft and the new will show the difference in the positions of the crank throws. The firing interval has not been altered, but the firing order has. This design of shaft gives perfect balance and therefore there is no vibration found in this eight-cylinder V-type engine.

Flywheel. There has long been a difference of opinion among the engineers as to whether the weight of the flywheel should be greater or less with respect to other features of design. Generally speaking, the slow-speed engines or engines such as are used in con-

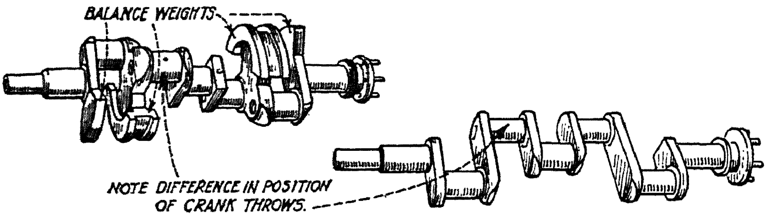


Fig. 8. Left—Cadillac Counterbalanced Crankshaft
Two throws are advanced 90° over the other two.
Right—Three-Row Crankshaft Formerly Used in Cadillac "V" Eights

tinuous service in buses or trucks are equipped with heavier flywheels than the engines in passenger cars.

Passenger-car engines are relatively slow speed when compared to racing-car engines, and here again there is a decided difference in weight. When attempting to speed up passenger cars for racing duties, one of the first things to be done is to lighten the weight of the flywheel as well as balancing it. This one point then may be conceded. The higher the speed of the engine and the more rapid the acceleration desired, the less the weight which should be confined within the flywheel.

There is just as definite a move in favor of considerable weight in the case of the crankshaft. One of the prime reasons for this is the fact that torsional vibration is less likely to be set up in a heavy shaft than in a light one. Another reason is that the more weight there is in the shaft the steadier the flow of power. Generally speak-

ing, the distribution of weight between the flywheel (or flywheels if two are used) and the crank counterbalances and the torsional balancers are items which are determined by the inherent design of the units which are to be assembled together to make a whole. The weight of the reciprocating parts also has a very definite bearing upon the design of the separate units.

Mounting Flywheel on Crankshaft. In the early construction of the car, the car manufacturers attempted to use some early machine-shop methods which gave them considerable trouble later. One of these was the pressing on of the flywheel on a tapered crank-

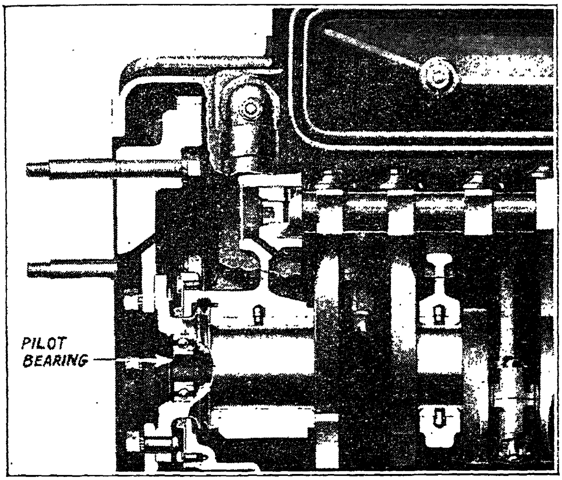


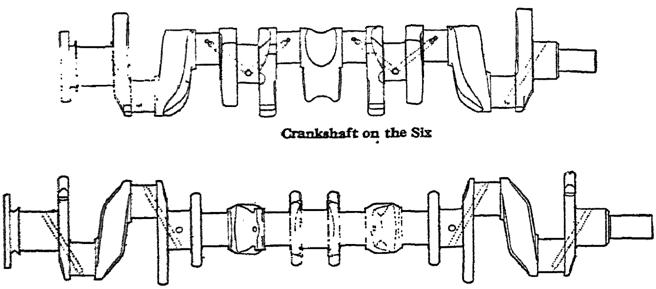
Fig. 9. Flywheel Bearing or Clutch Shaft Pilot Bearing

shaft end. These flywheels would work loose or they would become so tightly seized that it was practically impossible to remove them. A key and keyway were usually incorporated.

In the modern factories, the crankshaft is provided with a flange on which the flywheel is mounted by means of heavy flywheel bolts or machine screws. These in turn are locked by means of cotter keys. The rear end of the crankshaft is usually provided with a recess which will receive the small ball-bearing pilot which carries the forward end of the clutch shaft. This construction, illustrated in Fig. 9, is a standardized one.

In some cases the crankshaft flange is provided with dowel pins to locate the flywheel when assembling it. In other cases the holes drilled into the crankshaft flange are not evenly spaced. Where they are evenly spaced, it is possible to bolt the flywheel on in any position. When special provision for locating the flywheel is made, it is usually done with the idea of having the flywheel in balance with the crankshaft in one position only.

Most flywheels are designed to carry the clutch. Usually the inner surface of the flywheel receives the thrust from one of the clutch discs when the clutch is in. The rim of the flywheel is drilled



Crankshaft on the Six

Crankshaft on the Eight

Fig. 10. 1937 Pontiac Crankshafts
Courtesy of Pontiac Motor Company

and tapped so as to receive the cap screws which hold the single plate clutch in position, the single plate clutch now being used almost universally. Here again special methods of assembling are sometimes resorted to so that the clutch and flywheel may be assembled in but one position, the idea being to see that parts which are balanced cannot be assembled in a wrong position. The flywheel ring gear may be machined integral with the flywheel, that is, the teeth of the flywheel ring gear which are engaged by the starting-motor pinion gear are machined from the cast-iron metal of the flywheel proper, Fig. 7. In other cases, the flywheel is provided with a steel ring which may or may not be heat treated. Usually these rings are shrunk in position on the flywheel, no other means being used to secure them to keep them from turning.

The Pontiac crankshafts are shown in Fig. 10.

SERVICING CRANKSHAFTS AND MAIN BEARINGS

When a major repair is necessary on the crankshaft or on the main bearings, it is necessary to remove the engine from the frame of the car and completely disassemble the engine. Under these circumstances, it is advisable to have an engine stand on which the engine may be mounted for this service work, Fig. 11. These engine stands may be purchased through the jobbing houses and are adjustable for a great variety of engine forms.

In the smaller service stations the engine stand is not always used. In many cases the engine block is mounted on low horses

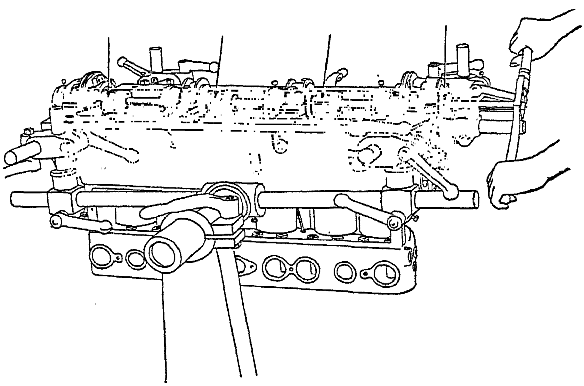


Fig. 11. Reaming Main Bearings (Note Arrows) with Engine Mounted in Engine Stand Which Provides for Rotation of Engine

(see Fig. 24). In other cases the mechanic uses wood horses or even heavy wood blocks. The main point, when doing bearing work, is to have the main bearings at a level that is convenient for speedy work.

Adjusting Main Bearings. It is not always necessary to remove the engine from the frame of the car when it is desired to take up on the main bearings or to adjust them for normal wear. Bearings may require adjustment after a season or two of use. Ordinarily the bearings should give a good many thousands of miles before this operation is needed. The actual mileage will depend upon the care the engine has received as well as upon the features of design.

Fig. 12 illustrates the method of placing a small piece of feeler ribbon or shim brass in a bearing cap when it is desired to test the

clearance between a bearing and crankshaft journal. According to the most usual specifications of the car manufacturers, splash-type bearings should be fitted with .001-inch clearance and pressure-fed bearings should be fitted with .002-inch clearance. Accordingly the shim or feeler ribbon used when making a test of the clearance in the bearing should be of .001-inch or .002-inch thickness, depending upon the type of oiling system used in the particular engine being serviced. When making the test to prove the amount of play in the bearings, the first thing to do is to drop down the bearing cap and place in the feeler strip, as shown in Fig. 12; then replace the bearing cap and draw the nuts quite snug. The next thing to do is to turn over the engine to see whether drag has been placed on the shaft. In many cases it will be found necessary to increase the thickness

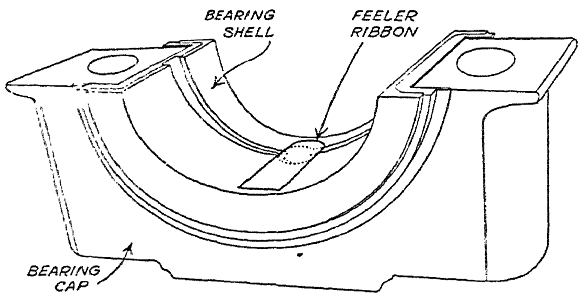


Fig. 12 Use of a Narrow Shim for Testing Main-Bearing Clearance

of the shim until drag is noticed. If a shim of .004 inch is necessary to place a slight drag on the crankshaft and the job is a pressure-fed type, it is then known that it will be necessary to remove .002 inch of metal from the bearing cap or else remove shims of that thickness.

After the bearing has been adjusted until proper clearance is secured for one bearing, the same method of procedure is followed for each of the other bearings in turn. It is a good plan to always back off the nuts holding the bearing cap in position about one-quarter or one-half turn after a bearing has been properly fitted. This will allow the work to proceed on the other bearings without securing a false test when testing for clearance. If the bearing caps are allowed to remain locked tight, there will be an increasing amount

of drag as each bearing is tightened or adjusted in turn so that when the last bearing is being adjusted, it will be found difficult to make an exact test of the proper amount of drag.

Crankshaft End Play. The end play of the crankshaft in the main bearings should be tested, because if it is excessive a knock will result, while if too little the shaft will bind on the end faces of the bearing and cause heating. The use of a dial indicator for testing crankshaft end play is shown in Fig. 13.

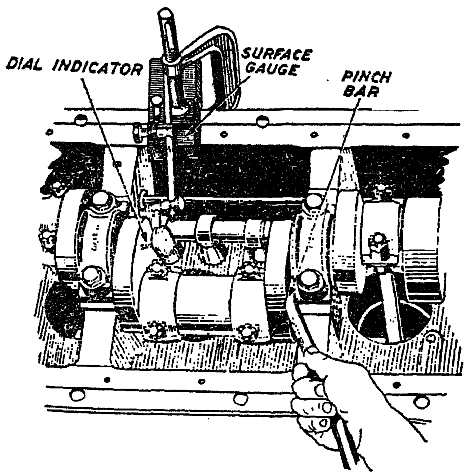


Fig. 13. A Dial Indicator Is Clamped to the Crank Case to Register End Play When Shaft Is Moved with Pinch Bar

Cadillac Series 36-60, 70 and 75 Main Bearings. When main bearings are found to be worn beyond .004-inch limits, they should be replaced. No attempt should ever be made to shim or otherwise take up worn bearings. Replacement main bearings are furnished to exact size and do not require reaming or scraping. They can be installed by removing the cap from the front main bearing and removing the worn bearing shell from the cap without removing the crankshaft. Next, rotate the crankshaft to turn the upper shell out of the crank case. No special tool is provided for this operation. Instead, a cotter pin should be placed in a vise and the rounded end flattened to a T shape. Then pin can be dropped into oil passage in journal and projecting head will contact bearing and force it out as shaft turns. (See Fig. 14.)

Place the new upper bearing shell on the crankshaft journal, with the locating lug in the correct position, and rotate the shaft to turn the upper shell up into position. Install the lower bearing shell in the cap and reinstall the cap. Repeat this procedure for each main bearing. New bearings will not provide satisfactory operation if the crankshaft journals are worn or scored.

Fig. 15 shows the ratchet handle and socket wrench used by many mechanics in adjusting main bearings. It will be noted that in every case socket wrenches are used, as this prevents the rounding of the corners of the nuts and insures speedy work.

Handling Shims When Adjusting Bearings. In a great many cases both in pressure-fed and splash-lubricated bearings, shims are used between the bearing halves. Fig. 16 illustrates the use of a shim board. It will be noted that the workman has driven nails into the board to accommodate the shims which are removed from

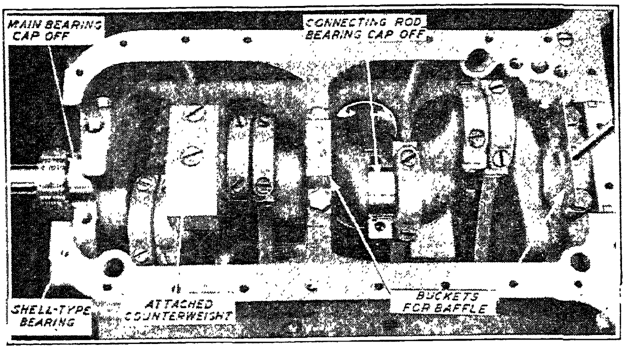


Fig. 14. Cadillac Crank Case with Pan Off—Series 36-60, 70 and 75
Note side by side rod assembly.
Courtesy of Cadillac Motor Car Company

the bearing studs. This simple arrangement allows the workman to keep the shims in a correct position at all times. It is not always possible to know that when a shim is removed that it will not need to be replaced. A bit of experimenting must be done until just the proper thickness of shim is discovered to give the exact bearing fit which must be secured.

Marking Main=Engine Bearing Caps. In many cases it is easy to identify the relative position of bearing caps. However, in the case of the front center and rear center main, shown in Fig. 16, this is not so readily done. In order to prevent any possibility of the bearing caps being confused with each other or turned end for end, it is a good plan to use a center punch to mark the bearing caps and crank case. If steel dies for numbering are available, the bearings should be numbered from the front toward the rear. File marks are also used by some mechanics. The main thing is to have some

form of identification so that the work may be done with the least confusion and loss of time.

Polishing Crankshafts. Very frequently it is found that it is impossible to adjust main-engine bearings, owing to the fact that the bearings themselves may be badly worn or scored and to the further fact that the crankshaft may be worn out-of-round or sprung.

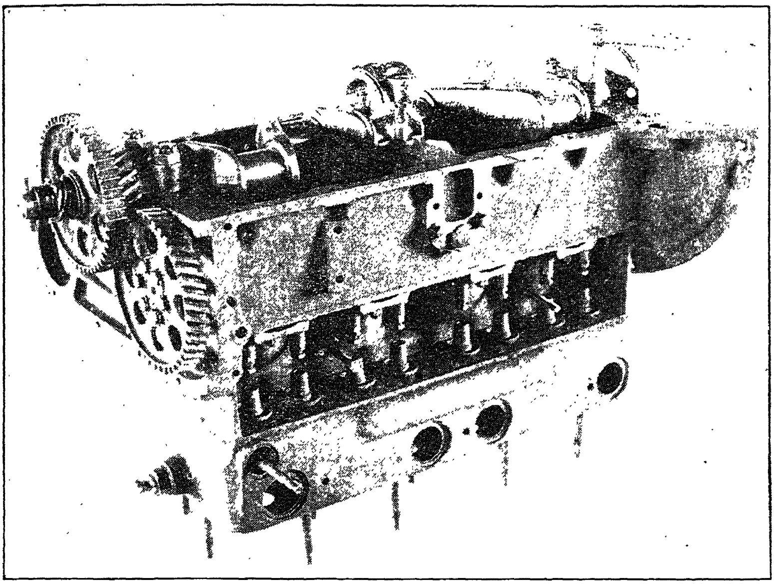


Fig. 15. Socket Wrench and Ratchet Handle Used for Running On or Off the Castellated Nuts Used to Hold the Bearing Caps in Position

The adjustment of bearings is only to be done when the engine is apparently in good condition except for slight bearing wear. Where considerable bearing work is required, as in a badly worn engine, the crankshaft should be removed and carefully inspected.

In practically every case it will be found that the crank-pin journals have become worn with slight ridges. It is possible to remove these by a simple hand operation. In this case, a strip of emery cloth is used and given one turn around the crank pin. By pulling the cloth forth and back, it is possible to polish out these slight scores or ridges.

Another method used is quite similar to this one. A patch of No. 0 or No. $\frac{1}{2}$ emery cloth is provided, which is just as wide as the

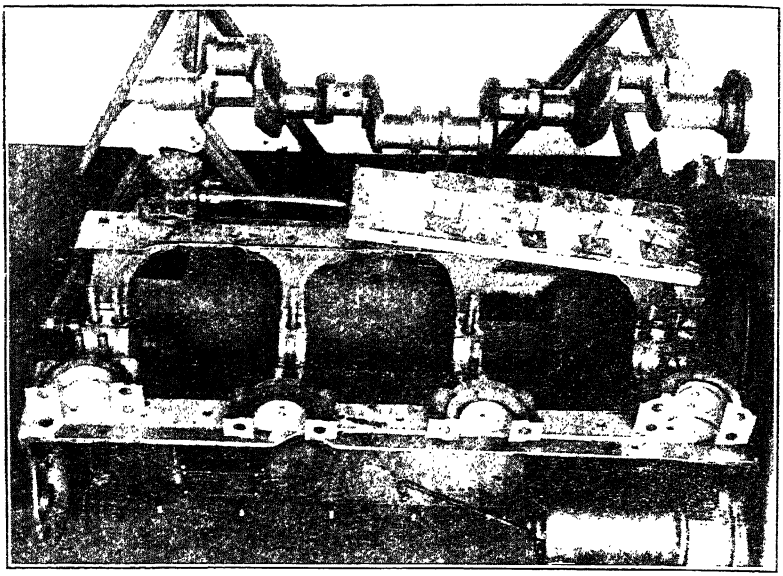


Fig. 16. The Shim Board Is Used To Keep the Shims in Position When Testing Main Bearings

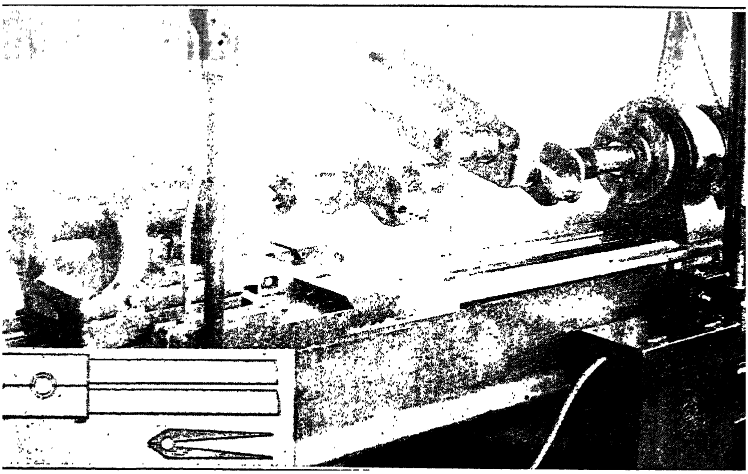


Fig. 17. Grinding or Lapping Crankshaft Mains and Crank Pins

crank-pin journal. A light leather strap or belt is passed around the patch and used to rotate the emery cloth patch on the crank-pin

journal. It will be found that this method is quite satisfactory in removing minor scratches.

Another method used in polishing crankshaft main bearings and pins is illustrated in Fig. 17. The inset in Fig. 17 shows several simple devices used for lapping or holding emery cloth when grinding the crank pins or mains. The crankshaft is mounted in the lathe and the lapping tool has emery cloth fitted to the two jaws. The lathe is operated at a slow speed and the workman applies the pressure from the handle of the jaws. After a bit of experience, it will be found possible to speed up the work, even on the crank pins, by adjusting the pressure.

Testing Crankshaft for Straightness. Before attempting to scrape bearings or refit them when the crankshaft shows considerable signs of wear, there are several tests which should be used. One of these is illustrated in Fig. 18, which shows a dial gauge which has been set up with the crankshaft in the V blocks of the arbor press. The workman is marking the high spot on the crankshaft, which has been discovered by rotating the crankshaft in the V blocks, with the dial gauge on the rear center main bearing. This particular shaft was found to be out .033 inch. The workman also marked the direction in which the force should be exerted when straightening the shaft, as will be noted in Fig. 19, which shows the same shaft in the arbor press.

When testing a crankshaft for straightness, it is better to use the V blocks under the front and rear main bearings than to place the shaft in the centers in the lathe. The latter method is satisfactory if care is used to see that the centers in the end of the crankshaft have not been marred. Not infrequently it will be found that these centers have received a blow and are no longer true with the journals. When making a test between centers in the lathe, the first thing is to check to see that the front and rear main-bearing journals run true with the centers. If they do not, it will be necessary to scrape the centers with a bearing scraper until the journals do run true with the centers. In order to avoid this laborious operation. it is best to use the V blocks.

Straightening Crankshaft in Arbor Press. Fig. 19 illustrates the method of setting up the crankshaft on the V blocks in the arbor press and applying pressure to the rear center main in order

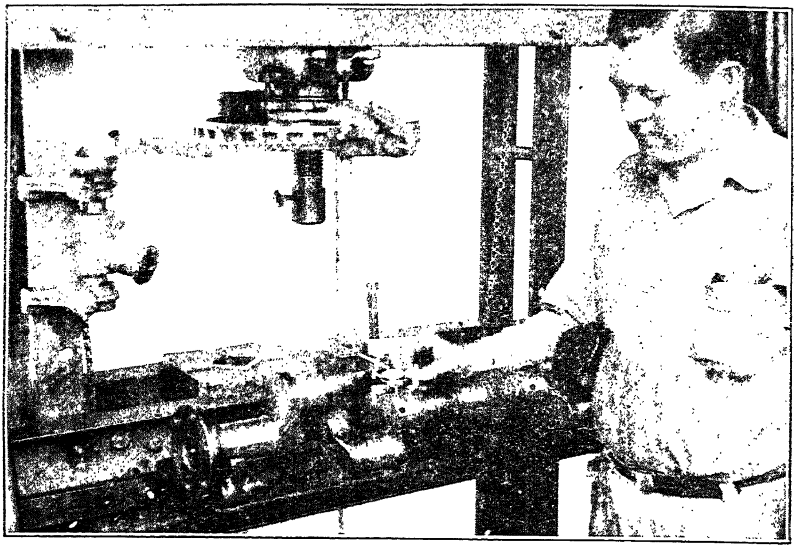


Fig. 18. Testing Crankshaft on "V" Blocks for Straightness
Chalk is used to mark the high points.

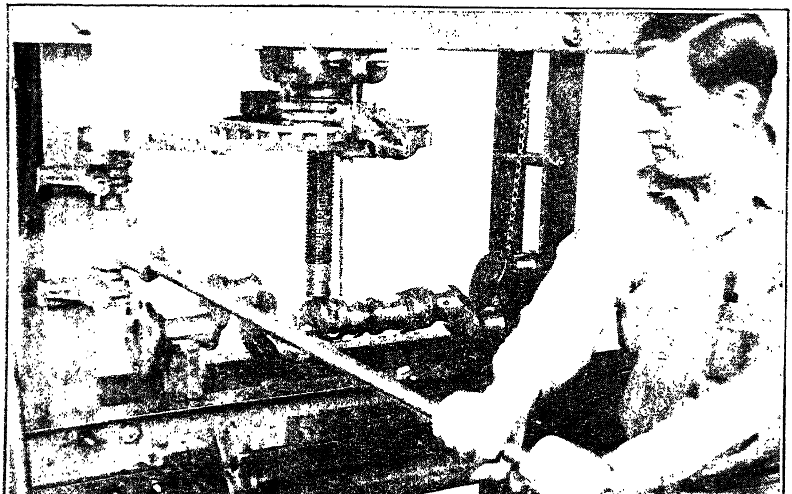


Fig. 19. Using an Arbor Press to Straighten a Crankshaft

to force it in the direction indicated by the arrowhead, placed on the shaft when it was tested, as illustrated in Fig. 18.

It will be found, when applying pressure to a crankshaft in order to straighten it, that considerable force will be necessary. In other words, it will be necessary to force the shaft a considerable distance past center in order to spring it back to its normal form. For this reason it is a good plan to make a number of tests to see how the work is proceeding. If a hydraulic press is used, the pressure gauge will show the pressure applied at any time. Where a screw press is used, as shown in Fig. 19, it is a good plan to mark the travel of the large wheel so that on each succeeding attempt the wheel may be turned a bit further than on the former one and the exact point of stoppage noted. A chalk mark on the wheel will serve for this.

Fig. 20. Checking Main Bearings by Means of Micrometer
This test shows taper and out-of-round.

Crankshafts are made from nickel steel, as a general rule, and for this reason are quite "springy." By using care, the ordinary case of sprung crankshaft may be remedied. The crankshaft should be brought within .002 inch of straight when tested, as shown in Fig. 18.

Testing Crankshaft for Taper or Out-of-Round. When checking a crankshaft, it is always well to have a piece of chalk handy to mark the points at which the measurements are made and at which variations are discovered. As a rule, a low point will be a quarter turn or ninety degrees advanced over the high point.

Fig. 20 illustrates the use of the micrometers for checking the main-bearing journals of a five-bearing eight-throw crankshaft. When checking the main-bearing journals for out-of-round, the

measurements are made at several points around the circumference of the journal until the high point is discovered. The reading of the micrometer should be recorded. The low point is then sought and that reading is likewise recorded. The difference between the two readings indicates the amount of out-of-round. If a main bearing journal or crank pin is out-of-round as much as .002 inch, it should be reconditioned. When checking for taper, the high point is again located near one of the ends of the journal and a reading is made and recorded. The micrometer is then moved to the opposite end of the journal and another reading is made and recorded. If there is a difference in the readings, it indicates the amount of taper in the journal.

Proceed to check the journal further to learn whether the taper is uniform or whether it is complicated by the out-of-round features of the journal. Not infrequently a shaft shows both taper and out-of-round, or the out-of-round may be such that it shows up only at one point on the journal, leading the workman to believe that taper alone is the cause of it. Generally speaking, if inaccuracies as much as .002 inch are discovered, the crank pin or main-bearing journal should be reconditioned.

A great many crankshafts are fitted to the main bearings by line reaming or line boring. When this is done, it will be impossible to secure a good job if the various mains and crank pins show taper. When hand fitting a crankshaft, taper does not spoil the job. It is impossible to fit bearings to an out-of-round shaft no matter what method is used.

When checking a crankshaft, as illustrated in Fig. 20, the work should be carried out systematically and a record made of all the readings. It is useless to attempt to carry the readings in the mind as mistakes are almost certain to occur. It is a good plan to start with bearing No. 1 and check it for out-of-round and taper, then proceed to bearing No. 2, and so on through all of the main bearings, and record the readings for each main bearing or crank pin.

A crankshaft gauge similar to that in use in Fig. 21 may be used in checking the mains and crank pins. This device is so designed as to record any variation over a predetermined setting. It does not give the diameter of the part to be tested. It simply records imperfections or variations. When placing the crankshaft gauge on

a main bearing, as illustrated in Fig. 21, the gauge is adjusted until it will read zero on the high spot. The gauge is then rotated until the low spot is found and the reading noted. Any variation from zero will be so much out-of-round.

By moving this device from one end of a main-bearing journal to the other, it is possible to determine the amount of taper caused by the wear of the shaft, if such has occurred. The crankshaft gauge is more easily read than the micrometers and a check-up is more quickly performed.

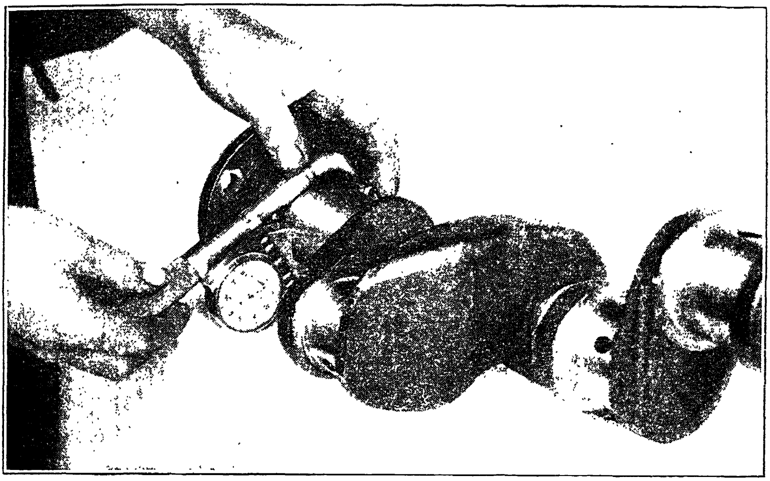


Fig. 21. Using Crankshaft Gauge to Test Crankshaft Mains and Crank Pins for Taper and Out-of-Round

Reconditioning Crank Pins and Main-Bearing Journals. Crankshafts, which have a variation exceeding .002 inch in the roundness of the crank pins or main-bearing journals, cannot be fitted to the bearing so as to secure satisfactory service. Fig. 22 illustrates the use of a hand-turning lathe or tool for reconditioning crank pins and main-bearing journals. This device may be used for crankshafts of varying diameters and for crank pins and main-bearing journals of varying lengths. All that is required is to adjust the opening of the throat on the device and select a cutting blade of proper width. When in use, the hand screw is used to turn the cutting blade in against the metal of the crankshaft. The device is then rotated around the crank pin or main-bearing journal by hand.

A careful study of Fig. 22 will show that the crank pin being reconditioned was considerably out-of-round. It will be noted that there are two white spots or streaks appearing on the pin where the blade has removed metal. These spots are not even. The dark parts illustrate metal which is still low. By using one of these devices, the crank pins are re-turned until they are true. If the blade is kept in good condition, the job is smooth. If there are minor

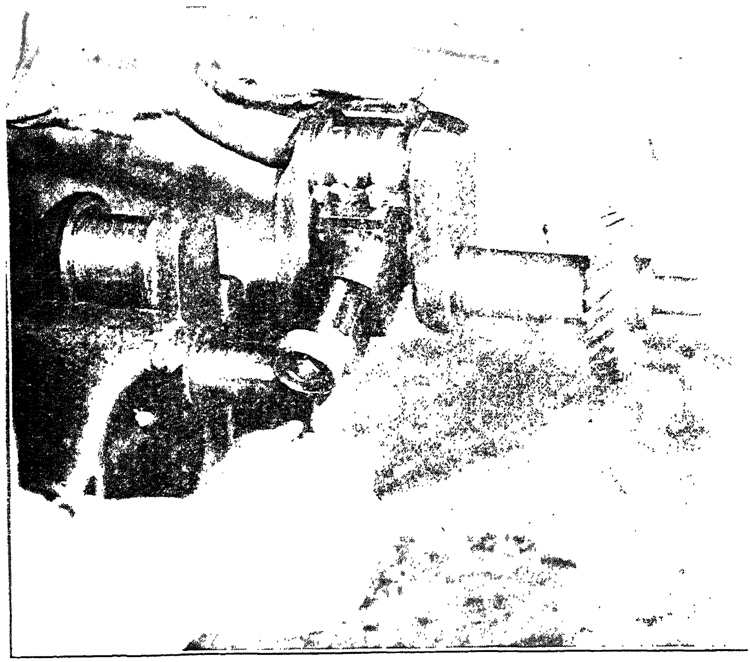


Fig. 22. Using Crank-Pin Turning Tool to Round Up Worn Crank Pins

scratches appearing after turning with the hand tool, these should be polished out.

Fitting Main Bearings by Scraping. Although many shops are using the line-reaming or line-boring machines for fitting main bearings, there are still many jobs which are best cared for by hand scraping, as illustrated in Fig. 23. The picture shows a mechanic scraping away the high point secured from the impression. He is working on a bearing of a truck engine. The inset, Fig. 23, shows

the method of gripping the scraper handle and blade as well as the position of the blade with reference to the bearing metal.

The crankshaft being fitted by the mechanic in Fig. 24 has been reconditioned by the method illustrated in Fig. 22. It will be noted that the crank pins are clean and bright.

In order to secure an impression on the bearing metal, the mechanic uses a very small quantity of bearing blue. This bearing blue is distributed evenly over the surface of the main-bearing journals. Avoid using too much blue. The crankshaft is then placed in position, as shown in Fig. 24, and rotated several times

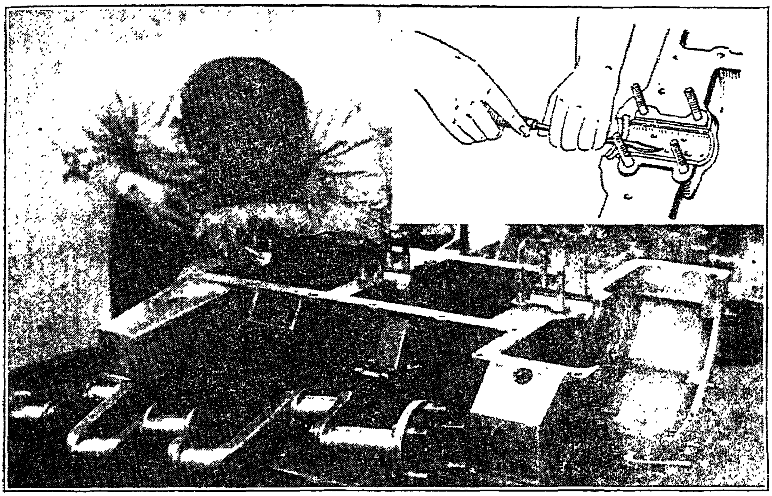


Fig. 23. Scraping Main Bearings

under pressure, from the hands of the mechanic. The crankshaft is then lifted out and laid to the side. An impression similar to that shown in Fig. 25 will be noted. The mechanics very frequently protect the ends of the bearing studs by means of tape. This feature is also illustrated in Fig. 25.

When securing an impression such as that illustrated in Figs. 25 and 26, it is necessary to lay the crankshaft in the main bearings and rotate it forth and back by hand. This process is illustrated in Fig. 24, both in the photograph and in the inset.

Fig. 25 illustrates the bearing scraper in position for cutting off the high spots, as indicated by the impression. The bearing scraper is swung sidewise, giving it a swinging, scraping motion. After a little practice, it will be found possible to have the scraper cut clean and free. Avoid chattering or any motion which tends to give a notched or nicked effect.

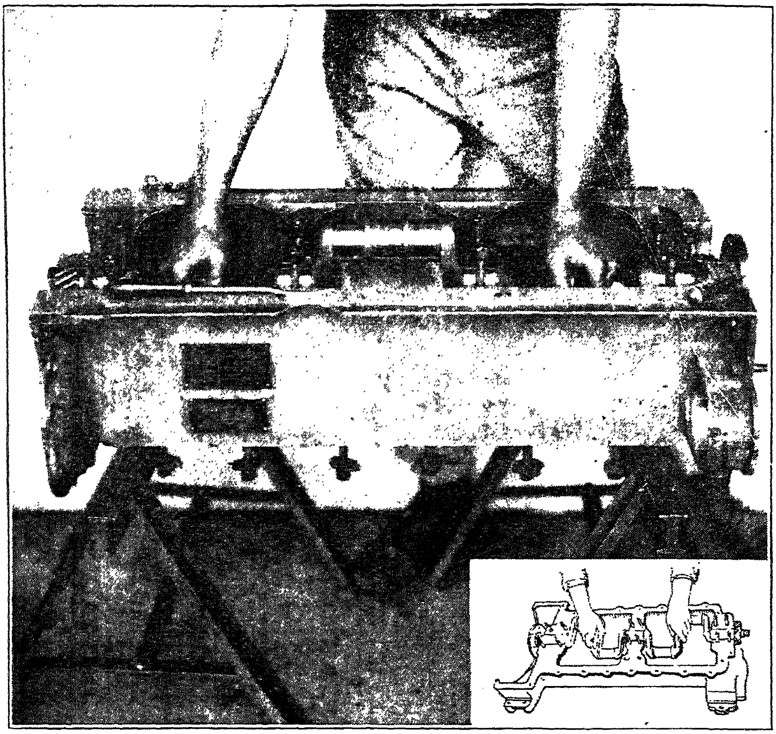


Fig. 24. Getting an Impression When Fitting Crankshaft to Main Bearings by the Scraping Process

Bearing scrapers are sharpened by placing the blade flat on an oil stone and rotating the blade round and round, just as in whetting any edged tool. Under no circumstances must the blade be rocked in order to have the stone cut faster near the edge. This would give a rounded edge which would be entirely worthless for scraping. After having whetted the scraper on the bottom, it may

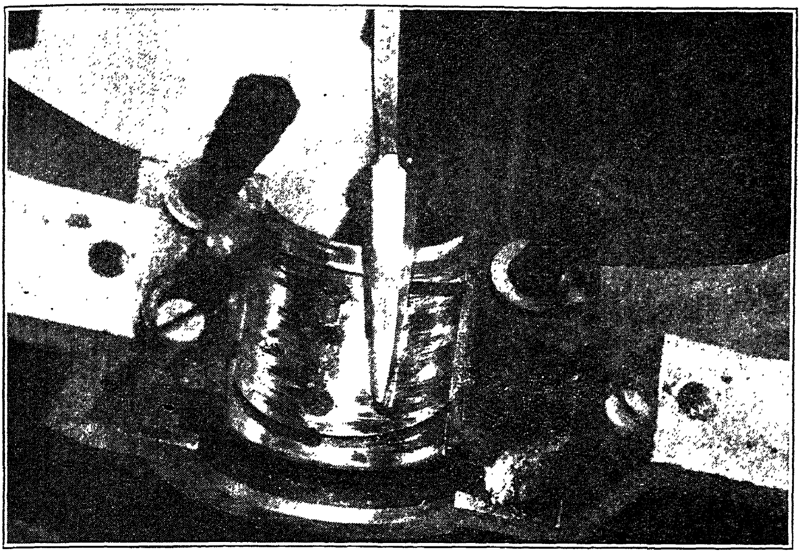


Fig. 25. Close-Up View of a Rear Main-Bearing Upper Half, Showing the Impression Made in Fig. 23
The Scraper is shown in position for removing the high spots, which show up dark.

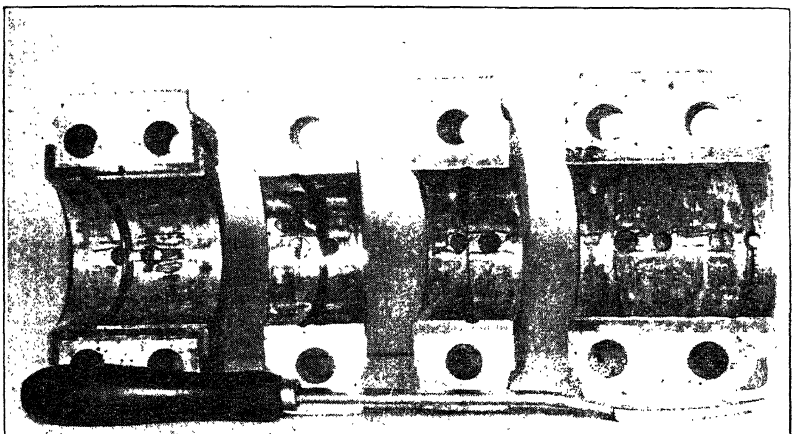


Fig. 26. Set of Main-Bearing Caps with the "Impression" Off
At least a 75 per cent bearing is required.

be laid on edge and further whetted. The edge of the scraper should not be sharp as a pocket knife is sharp, but it should be free of all nicks and absolutely clean cut.

When scraping main bearings, all of the upper halves must be scraped and worked together. Not infrequently it will be found when the first impression has been made that the center mains are low, that is, they have received more wear than the ends. Consequently it will be necessary to remove metal from the end bearings so as to bring the shaft in contact with the center mains.

In removing metal, owing to the circular form of the bearing, more metal will need to be removed from the bottom of the bearing than from its sides. It will be seen that if the workman should carelessly remove considerable metal from the sides, there would be no way of bringing this metal into contact with the main-bearing journal. In fact, considerable care must be used when fitting bearings by the scraping process lest too much metal be removed and trouble be encountered elsewhere, as would be the case if the timing gears were thrown in too deep mesh by removing too much metal from the front main bearing.

The scraping process should continue on the upper halves until approximately a 75 to 85 per cent contact shows. A study of the bearing caps shown in Fig. 26 will illustrate this very nicely. Those parts within the bearings which show dark are portions of the bearing which have been in contact with the main-bearing journals. The largest one at the right shows the best impression of any of them. This perhaps could be passed as a 75 per cent bearing. The others show less than 75 per cent. If too much bearing blue is used, it is quite easy to gain a false impression and believe that you have a 75 per cent bearing when, as a matter of fact, the bearing may be less than 25 per cent.

After the bearings have been scraped until the proper impression is secured for the upper halves, the workman will then start fitting the bearing caps, one at a time. Some mechanics prefer to start with the center and work toward the ends. Others prefer starting with the rear main and work toward the front. Still others start from the front and work toward the rear. This is rather immaterial, the main idea being that each cap shall be carefully scraped and fitted until it shows a proper impression.

A bearing with a 75 per cent contact will offer considerable resistance to the rotating of the shaft. However, it should be possible to turn over a shaft, with one bearing locked down, by means of a twelve-inch bar. After one bearing has been fitted, the lock nuts may be backed away a trifle so as to free up that bearing. The other bearings are then fitted in turn until all have proper contact, after which they may be locked down and the whole job run in.

Caution. The point at which many beginners fail when scraping bearings is in not using proper care with reference to the shims under the bearing caps. To all intents and purposes, the upper half and lower half of a bearing should be locked together rigidly. Under

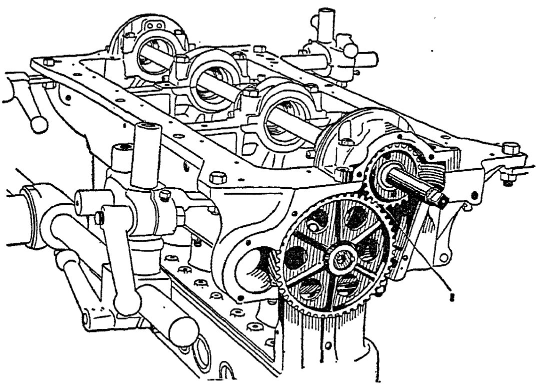


Fig. 27. When Setting Up the Main Bearing Reamer or Boring Bar, Always Check Gear Lash as Indicated at Arrow 1

no circumstances should there be any clearance between the parts of the bearing cap which come in contact with the crank case on the flat portions, that is, the portions surrounding the bearing stud holes. Bearing caps must be reduced by filing or scraping. In case too much metal is removed, brass shims must be inserted in order to show proper clearance. In some cases thin shims are removed rather than reduce the cap. Whether shims are used or not, the bearings must be locked together rigidly to prevent any play between upper and lower halves. Not infrequently the beginner will simply back off on the castellated nuts used to lock the bearings in position. This is the worst fault possible and will result shortly in bearing failure. If job is too tight, remove bearing cap and free it by further scraping or insert a thin shim and lock the parts rigidly and insert cotter keys.

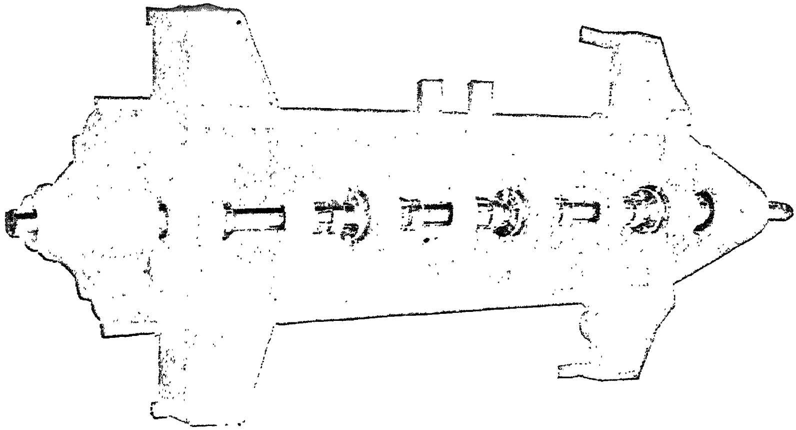


Fig. 28. Alignment Reaming Seven-Bearing Crankshaft

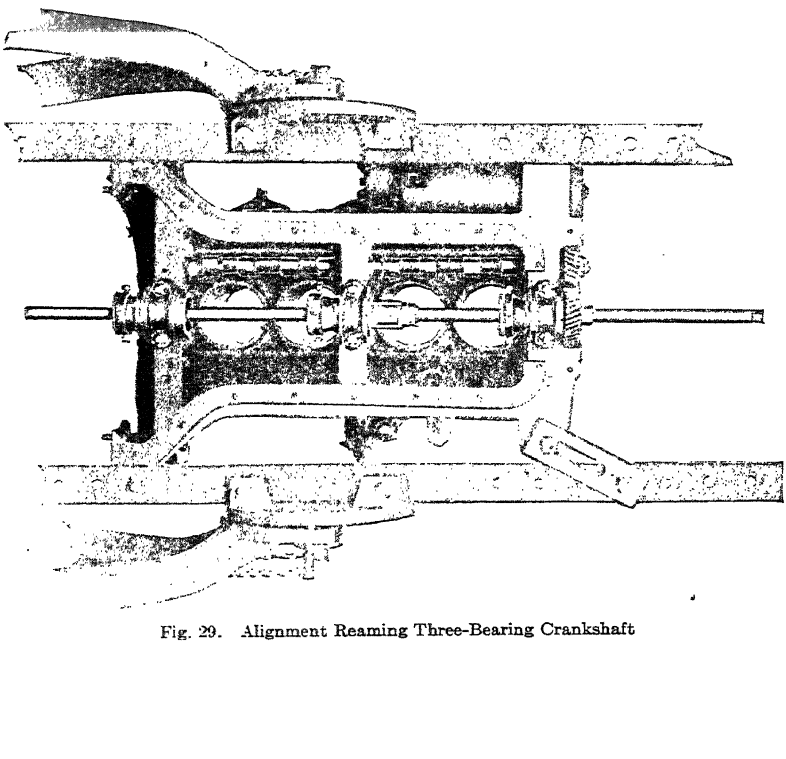


Fig. 29. Alignment Reaming Three-Bearing Crankshaft

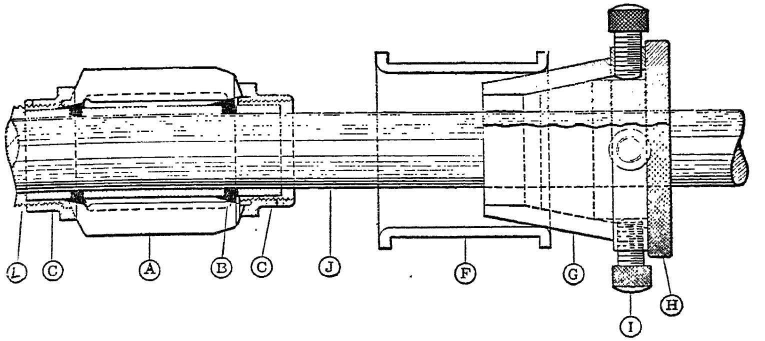


Fig. 30. Parts of Alignment Reamer

A—Reamer Cutter
B—Adjustment Wedges
C—Locking Nut
F—Bearing
G—Threaded Sleeve
H—Adjustable Bushing
I—Adjusting Screw
J—Reamer Bar
L—Thread Adjustment

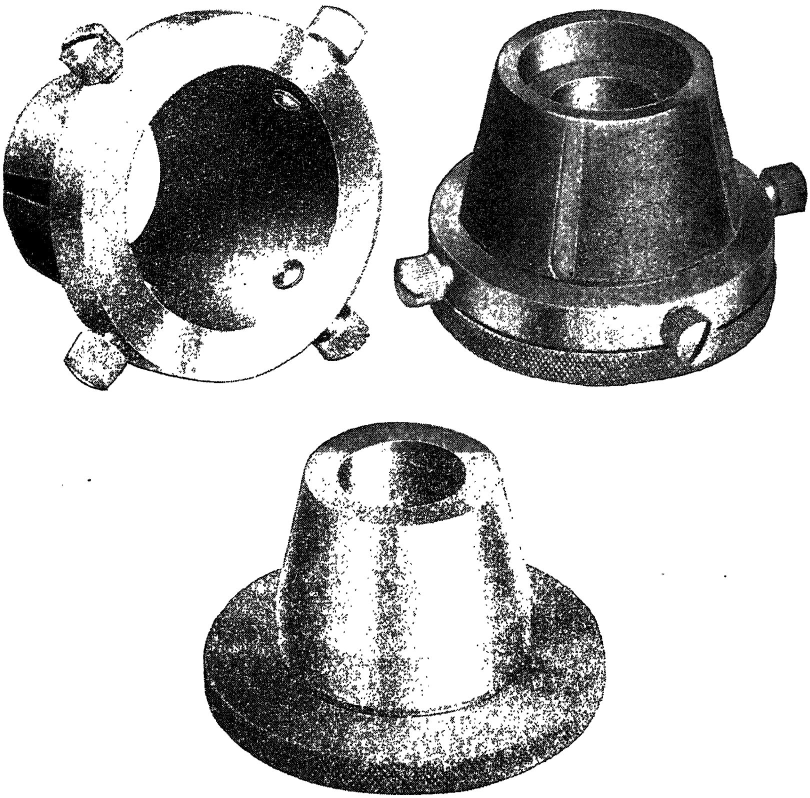


Fig. 31. Tapered Bushings Used for Aligning Reamer Bar

Fitting Bearing by Alignment Reamer. Play in timing gears is important for quiet operation. Back lash or play should be tested as shown in Fig. 27. The best, quickest, and cheapest way of fitting main bearings is to use an alignment reamer as shown in Figs. 28 and 29. Fig. 30 shows the parts of tool and reamer. The method of using the reamer is as follows: The caps, with the desired amount of shims between them and the crank case, are bolted into place just as they would be if the shaft was in place. The diameter of the shaft should be obtained and the micrometer adjustment on the reamer set to the size of the shaft plus a certain amount for an oil film. The reamer bar should be passed through the bearings, and the tapered bushings, Fig. 31, should be put into position, Fig. 29. The reamer, Fig. 32, may then be fastened to the bar and the first bearing reamed. Remove the tapered bushing from the next bearing and insert in the reamed bearing which will support the bar while the next bearing is being reamed. This process is repeated for all the bearings. The type of reamer shown has an adjustment whereby a set-up is permitted which will remove more metal from one side of the bearing than from the other. This is especially useful in bringing the crankshaft and camshaft into proper relation with each other and in maintaining proper compression.

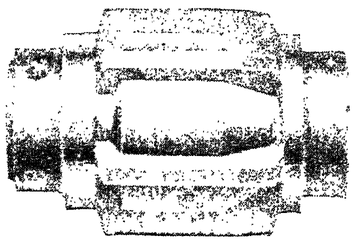


Fig. 32. Reamer Head Used for Line Reaming Main Bearings

This reaming method can be used when a new set of babbitt bearings have to be fitted. In the fitting of new bearings it is necessary to make new shims to go between the faces of the bearing. Obtain the diameter of the crankshaft and deduct the inside diameter of the bearing. Deduct the amount to be reamed out and the answer will be the thickness of the shims. For example:

Diameter of the crankshaft	2.875
Diameter of bearings	2.800
	.075
Amount to be reamed out	.040
Proper thickness of the shim	.035

The thickness of the shim that is placed between the bearing and the case should be the same for each bearing.

Machining Crankshafts in Lathe. It will be noted that the jig on the end of the crankshaft has centers provided. These centers are in line with the center of the crank pins. When performing the turning operation in the lathe, the shaft is mounted as shown in Fig. 33, which shows a form of jig or lathe dog used for mounting the crankshaft, with the crank pin centered, for the turning operation.

The machining of crank pins in the lathe is an operation which requires extreme care on the part of the operator, both in regard to his own safety, since the shaft turns with an eccentric motion, and

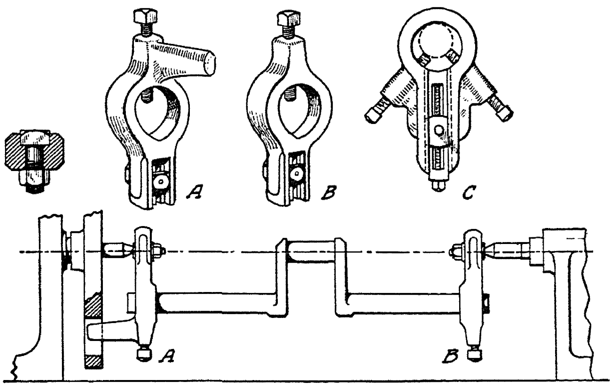


Fig. 33. Dogs with Adjustable Bearings Used for Turning Crank Pins in the Lathe

in having the center of the crank pins exactly aligned. This is an operation which is ordinarily performed in specialty shops, and those dealer agencies and independent repair shops which have this type of work to be done ordinarily send the work to a special automotive machine shop which is equipped with proper turning equipment.

Fig. 34 shows a crankshaft set up in the lathe ready for the crank-pin turning operation. The Norton throw centers are used in this case. These are adjustable so as to insure correct alignment of the shaft before the turning operation proceeds.

Fig. 35 illustrates the method of setting up a crankshaft for testing in the lathe and turning the main bearings. Fig. 36 shows the turning operation being performed in the lathe on the main bearing journals.

Fitting New Flywheel Ring Gear. One of the most frequent troubles arising in connection with the flywheel is the wearing away or the breaking of the teeth which are provided on the rim of the

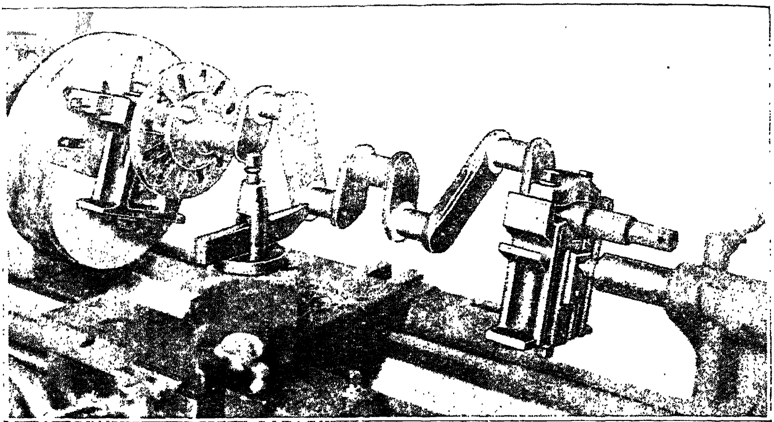


Fig. 34. Truing Crankshaft Throw Bearings, Using Norton Throw Centers
Courtesy of South Bend Lathe Works

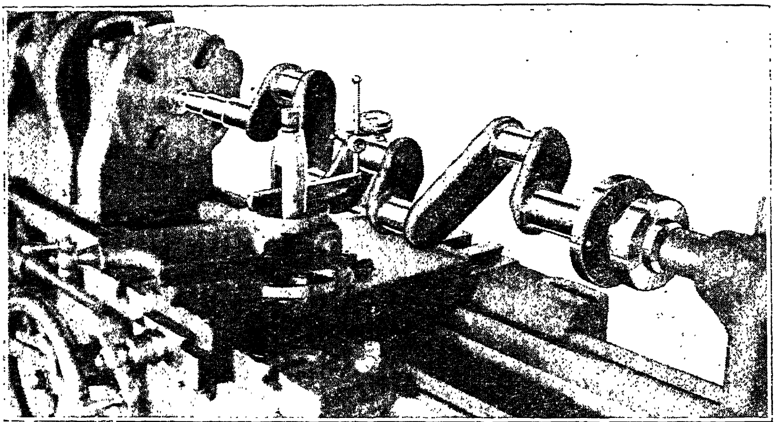


Fig. 35. Testing a Crankshaft in the Lathe with a Dial Test Indicator
Courtesy of South Bend Lathe Works

flywheel for engaging the Bendix drive pinion. Owing to the fact that the engine will always stop on compression when the ignition is shut off, the Bendix pinion usually engages at one certain position,

with the result that considerable starting may result in the teeth being ground or chewed away, as shown in Fig. 37. The mechanic is lining up a flywheel in the chuck of the lathe preparatory to turning off the old flywheel teeth and installing a new ring. The new steel ring which is to be installed shows on the lathe carriage, at the right of the picture.

Some manufacturers install flywheel rings made from steel and many others hold to the practice of machining the teeth in the cast iron of the flywheel itself. Naturally the teeth of the steel wheel are stronger than the teeth machined in the cast-iron flywheel.

If one cylinder of an engine or a pair of cylinders, having the crankshaft throws in line, happens to have unusually good compression as compared to other cylinders, the engine will stop in practically all cases at the same point. If the cylinders have even compression, there will be two points where the teeth will be worn for a four-cylinder engine and three points for a six-cylinder engine. Sometimes, when rebuilding a car, it is possible to advance the flywheel a quarter turn or a sixth turn, in which case the wear will come at a new point on the teeth. This is not always practical, owing to the fact that some flywheels are balanced in relation to the crankshaft and dowel holes are provided so as to prevent mounting the flywheel in any position but the one for which it has been balanced.

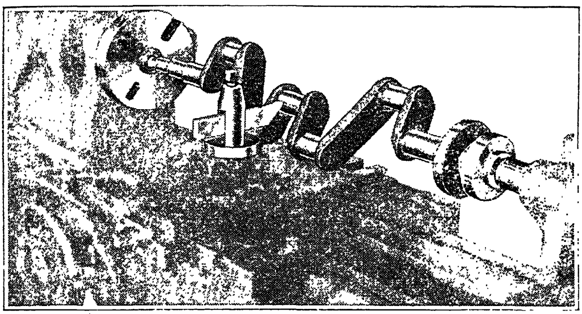


Fig. 36. Truing the Main Bearings of a Crankshaft
Courtesy of South Bend Lathe Works

Some repair shops are fitted with lathes suitable for doing this repair operation. In other instances it is necessary to send the flywheel out to a specialty shop in order to have the old flywheel turned down and a new flywheel ring gear installed. When this work is done, the first thing is to set up the lathe with the chuck, as shown in Fig. 37. The work may be done by bolting the flywheel to the face plate of the lathe. The next step is to see that the flywheel is

accurately trued up in the lathe. Fig. 37 shows the use of a dial gauge mounted in the tool post on the lathe carriage. By this method and working from the center hole of the flywheel, it is possible to have the flywheel mounted absolutely true.

The next step is to set up a round nose tool in the lathe and turn off the old teeth, having regard for the thickness of the metal of the new gear. Some mechanics use the cutting-off tool and cut under the root of the old teeth and then break them off.

Use a stiff joint outside micrometer to measure the diameter of the newly machined flywheel. Use a diamond pointed tool to cut

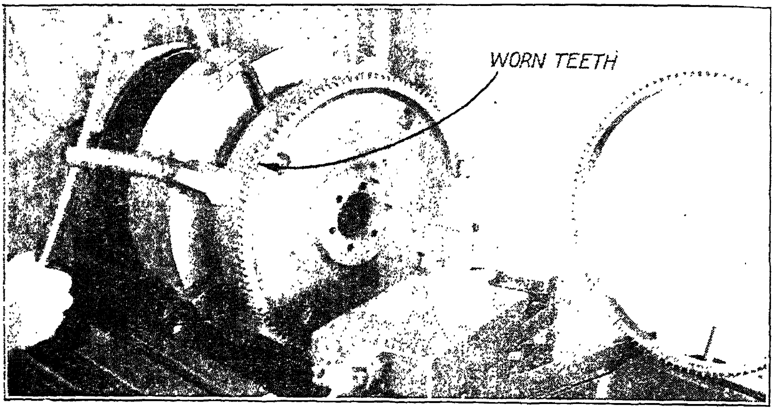


Fig. 37. Chucking a Damaged Flywheel for Machining Off the Teeth
Note the new flywheel ring gear setting on the carriage.

into the corner if it is found that a corner shows as the machining proceeds. This will usually be the case.

Most flywheel ring gears have the size to which the flywheel should be machined stamped upon the ring gear. This size has taken into consideration the amount of shrink necessary in order to secure the ring on the flywheel without pinning or other fastening outside of the shrink fit. The mechanic will be very careful to secure the exact measurement and see that the shoulder, provided at the rear, is properly machined and the width of the machined portion is just equal to the width of the ring gear.

Another point of vital importance is to make certain that the new gear is being mounted carefully. In most cases these gears are

provided with the teeth rounded on one end. This is to allow the Bendix pinion to engage properly. Owing to the fact that some Bendix drives are outboard and some inboard, an inspection must be made of the job to make sure which edge is to be toward the front and which edge toward the rear of the engine when the ring gear is mounted in position on the flywheel. When applying the ring gear, a torch is used to heat it to a point where it has expanded sufficiently to slip into position on the flywheel without any driving. A little experience will show how much heat to apply. As a rule it is not

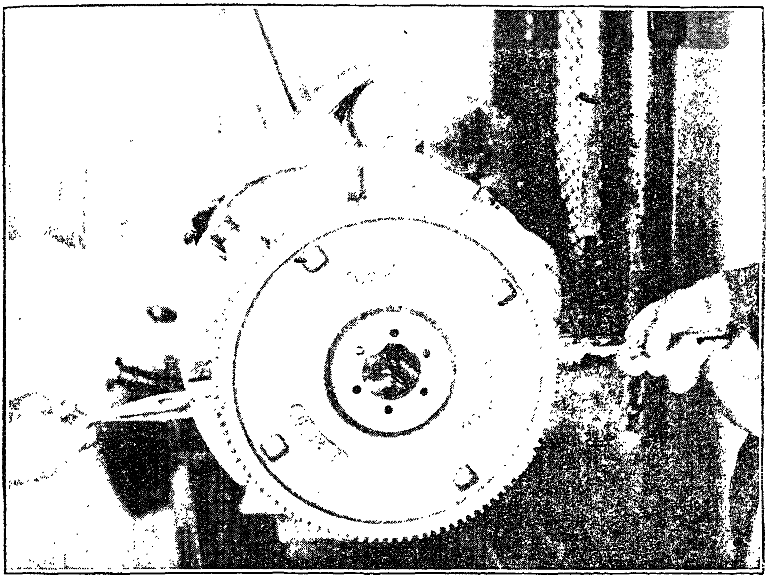


Fig. 38. Applying the New Ring Gear to the Machined Flywheel

necessary to bring the gear up to a blue heat. If blue appears on any point on the ring gear, the torch should be moved from that point quickly and heat applied more evenly. As a general thing, when the metal of the ring gear begins to show a straw color all the way round, sufficient heat has been applied.

Apply the ring gear to the machined flywheel as shown in Fig. 38. Make certain that the ring gear has come back against the shoulder. When this position has been secured, pour a bit of water on to the ring gear in order to cool it and contract it.

Packard Crankshaft Bearings on the 120 Packard Engine. The connecting rod and main bearings of the Packard 120 are of the non-adjustable type. The bearings are steel-backed, babbitt-lined, and there are five main bearings, giving a firmly supported shaft. The bearings are fitted with from .001-inch to .003-inch clearance. The crankshaft is carefully balanced both statically and dynamically, and is also counterweighted.

The connecting rods are of the steel-backed, babbitt-lined type, and are selected to insure .0005-inch to .0015-inch clearance. The thrust faces should be in line and the allowable end clearance is .004 inch to .010 inch.

The Packard Motor Car Co. advises that there should never be any metal removed from connecting rod bearings, caps or rods. There is no method by which these bearings can be adjusted.

Buick Main Bearing. The 1937 Buick engines make use of five main bearings. These are steel backed, babbitt lined and are locked in the crank case and bearing caps by offset tangs at the parting line. The bearing caps are inset in the crank case to insure uniform clearance and maintain alignment. When replacing bearings, it is necessary to replace the entire set.

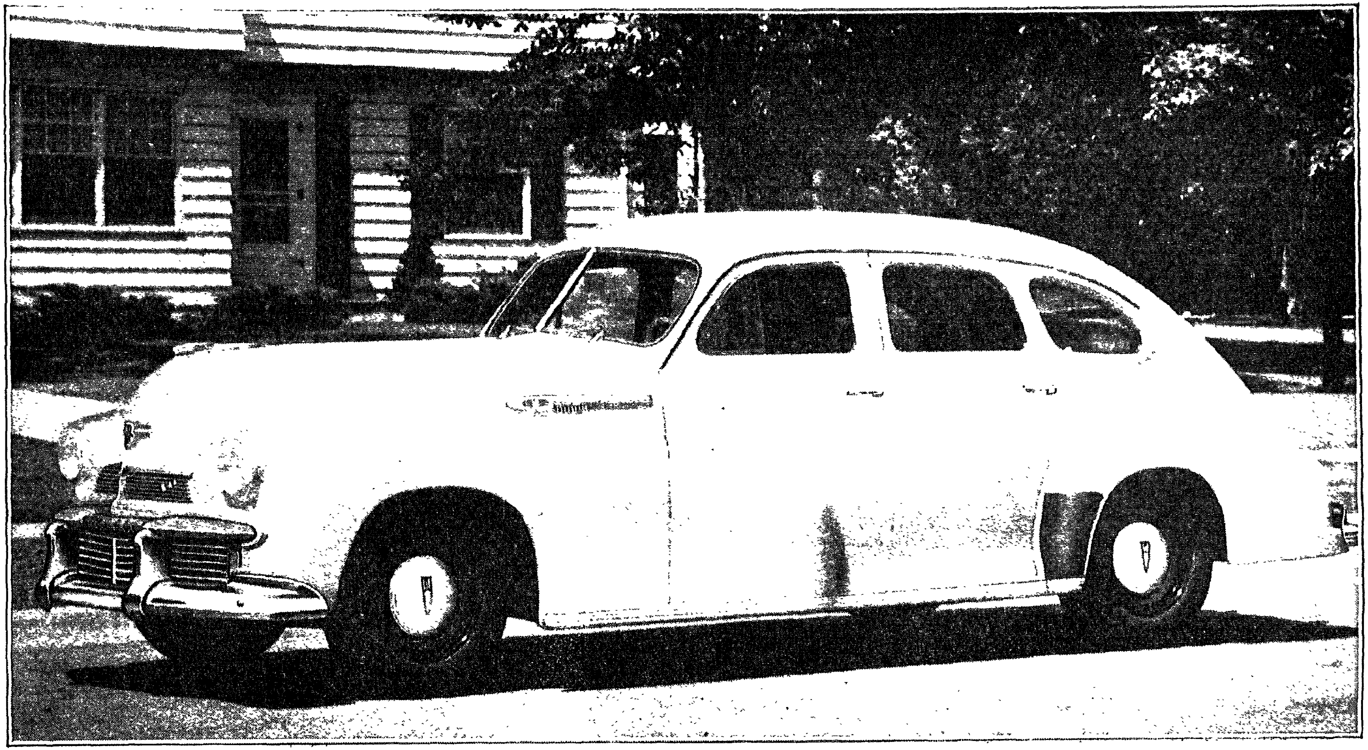
There are two methods of replacing the Buick bearings. One of these is to secure the production main bearings in .0014 inch oversize, which means of course that the line boring bar must be used to remove the surplus of metal. The alternate method is to secure the five main bearing sets from the dealer in finished reamed condition. They must be applied as a set. Shims are provided in the engine main bearing so as to allow adjustment for wear. Under no circumstances should the main bearing caps be filed to secure wear, but if all shims have been removed, then new bearings should be installed and reamed or the finished reamed bearings used.

Fitting Pontiac Main Bearing. It is recommended that the crankshaft be inspected carefully to see whether it is scored or whether more than .001-inch taper or out of round wear has occurred. If such condition is found, the crankshaft should be replaced.

When fitting the main bearing, make use of a .002-inch brass shim $\frac{1}{2}$ inch wide and 1 inch long, pressing it in the center of the cap. Next, assemble the cap to the bearing, drawing the bolts up

snug. Test the fit of the bearing by attempting to rock the flywheel by hand. The flywheel should not be moved more than 1 inch in either direction. If more than this movement is given to the flywheel, it may result in harm to the bearing.

When this work is being done, the greatest diameter of the shaft is found and should be in a vertical position. With the bearing cap locked tight in position, the .002-inch shim in place, the standard size bearing being used, the flywheel should be locked. If it is found possible to rock the flywheel and shaft easily with the .002-inch shim in place, a .001-inch undersize bearing should be used. No shims are used in the Pontiac bearings. Adjustment is by replacement of shaft or bearings.



1942 OLDSMOBILE "70" SERIES FOUR-DOOR SEDAN
Courtesy of Olds Motor Works

CRANKSHAFTS

PONTIAC MAIN BEARINGS

The main bearings on the Pontiac 1938 engine are of the steel back babbitt faced type and the upper and lower halves are interchangeable.

No shims are used, and to insure correct clearance the bearing caps are inserted in the block. Bearings can be easily replaced, without removing the shaft from the engine, in the following way: A $\frac{1}{8}''$ by $1\frac{1}{2}''$ cotter key, shaped as shown in Fig. 1, may be placed in the oil hole in the crankshaft, and then by rotating the shaft in the proper direction of rotation the bearing will be removed easily.

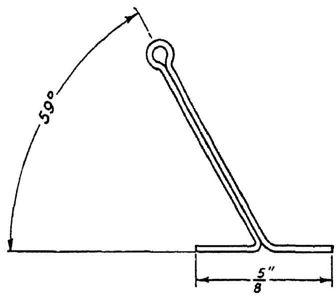
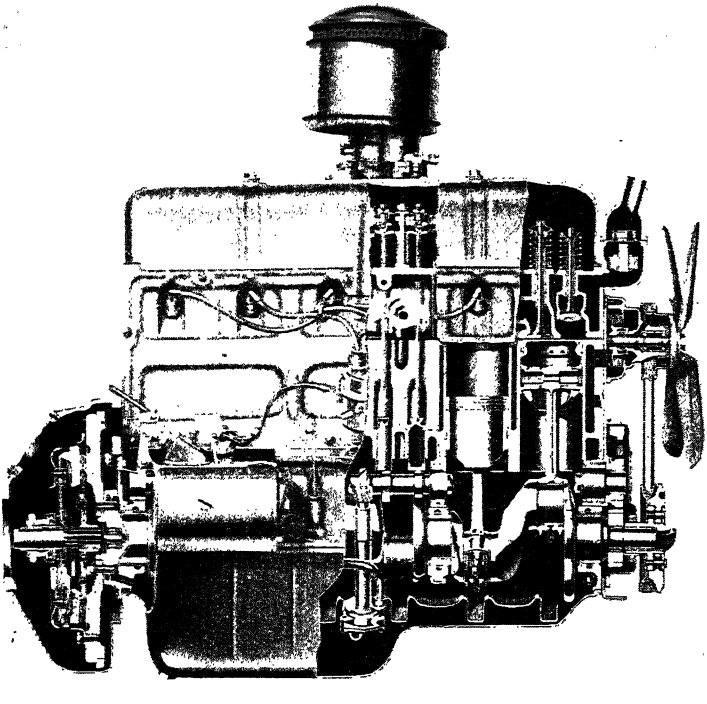


Fig. 1. Cotter Key

To replace the upper half of the bearing, the plain edge of the bearing should be inserted in the indented side of the upper bearing holder, and it can be put into position by gently rotating the shaft and bearing.

Strict instructions are given by the Pontiac Company that bearing caps should never be filed to take up bearing play. Bearing caps are part of the cylinder block assembly and should not be serviced separately.



SECTIONAL VIEW OF 1946 CHEVROLET ENGINE
Courtesy of Chevrolet Motor Division, G.M.C.

CRANKSHAFTS

THE CHEVROLET HARMONIC BALANCER

The 1939 Harmonic Balancer is designed to damp out crankshaft torsional vibration, by means of a flexing medium which consists of a pair of rubber annular rings, as illustrated in Fig. 1. Each

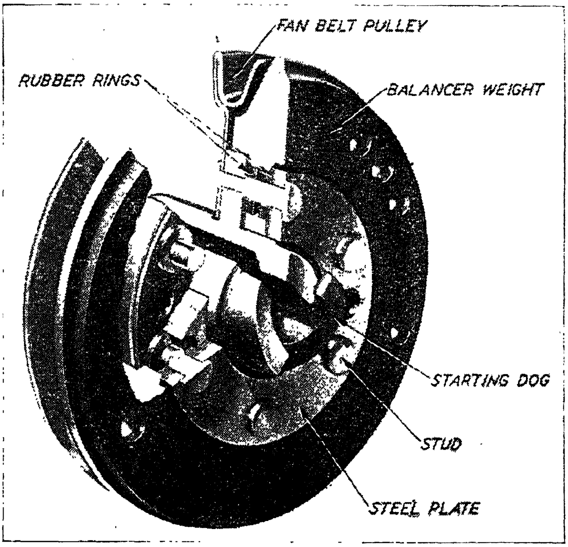


Fig. 1. 1939 Chevrolet Harmonic Balancer
Courtesy of Chevrolet Motor Division, G.M.S.C.

of these rubber rings has six raised bosses of rubber on one face and when the rings are placed over the six studs riveted to the hub, the six bosses of rubber form a bushing of rubber around each stud. The Harmonic Balancer weight floats on these bushings and is completely insulated with rubber from the hub, both in lateral and rotative movement. The ends of the studs are riveted over an annular steel plate which serves to maintain the assembly. The unit comprises within its design the dogs for the starting crank and the fan belt drive pulley.

1939 PONTIAC ENGINE REAR MAIN BEARING OIL SEALS

In the case of the 6-cylinder 1939 Pontiac, the oil seal is illustrated in Fig. 2. An angular groove is machined in the cylinder block and cap just behind the rear main bearing. A specially formed asbestos oil seal packing and retainer are assembled in this groove. The oil throw ring which is machined on the crankshaft is designed to throw any oil from the edge of this ring into the packing retainer which is so constructed as to drain the oil back into the crankcase,

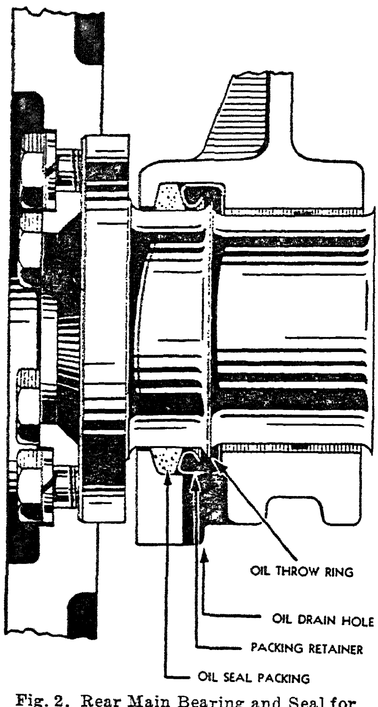


Fig. 2. Rear Main Bearing and Seal for 1939 6-Cylinder Pontiac
Courtesy of Pontiac Motor Division, G.M.S.C.

as illustrated. In order to install a rear main bearing oil seal on a 6-cylinder job, the crankshaft and rear bearing shells must be removed, after which press the upper half of the packing and retainer into the block. It is necessary to make use of a mandrel the same size as the crankshaft journal in installing the new oil seal. A lead hammer is used on the mandrel to hammer the packing down and

force it into the space provided for it. After it has been shaped and formed into the space designed, the ends should be cut off clean with a sharp knife, cutting the ends just flush with the bearing cap seat. The same manner of procedure is used for assembling the seal in the cap. The workman must remember that the packing retainer used in the bearing cap has two locating tangs, while the retainer used in the block is a plain one.

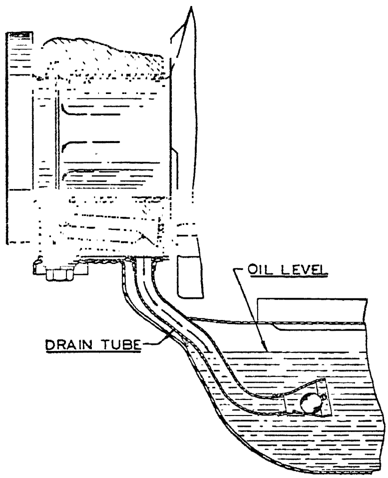
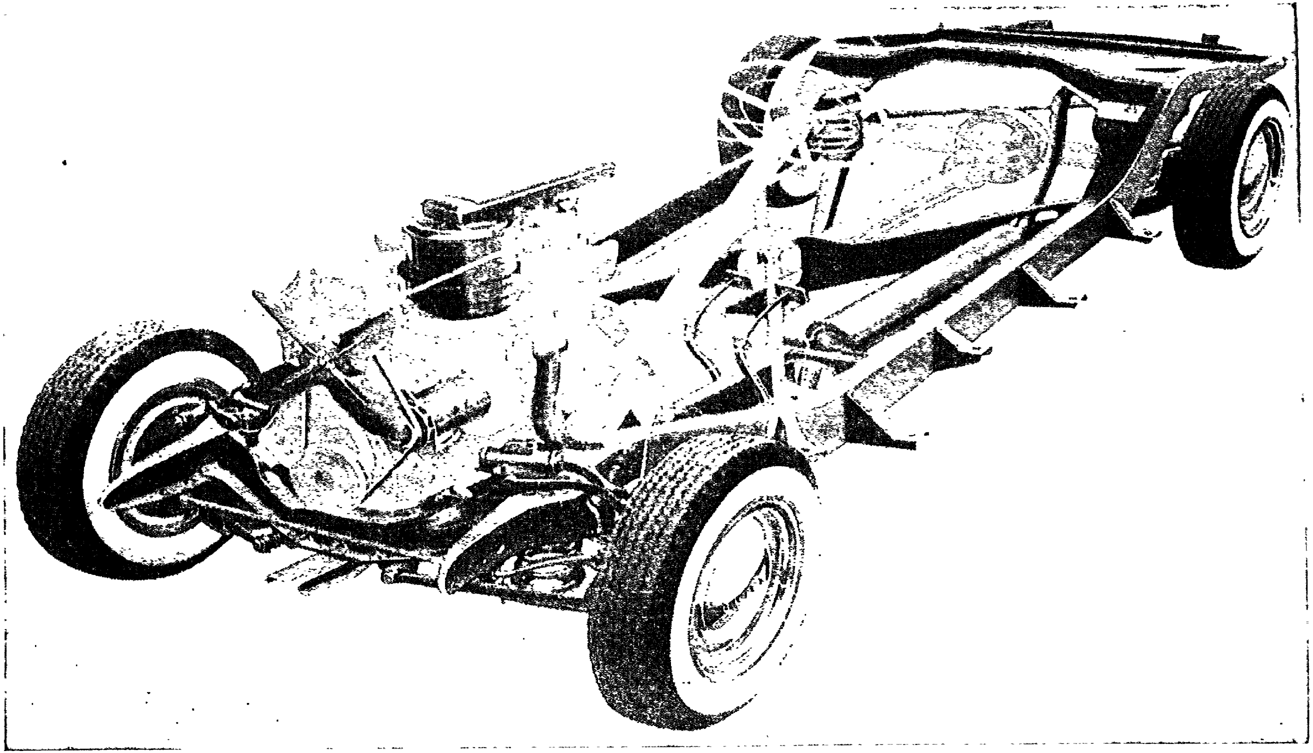


Fig. 3. Rear Main Bearing Oil Seal for 1939 8-Cylinder Pontiac
Courtesy of Pontiac Motor Division, G.M.S.C.

The oil return in the case of the 8-cylinder Pontiac engine is different, being illustrated in Fig. 3. Here it will be noted that the oil, finding its way through the rear main bearing will be thrown off by the oil throw ring into a groove provided in the bearing cap and in the cylinder block. This oil groove is connected through the cap by means of a drilled passage, which in turn is connected to a tube in such manner as to allow the oil to drain from the cap back into the oil sump.



1946 BUICK CHASSIS SHOWING VALVE-IN-HEAD DYNAFLASH ENGINE
Courtesy of Buick Motor Division, G.M.C.

CRANK CASES AND ENGINE LUBRICATION

CRANK CASES

The crank case together with the oil pan forms a housing for the crank shaft, cam shaft, connecting rods, oil pump, and other moving parts of the engine. This housing must be oil tight except at such points as those at which ventilation is provided. Gaskets are used when assembling the several parts of the crank case and oil pan assembly, so as to prevent the entrance of water or dirt from the outside as well as to prevent the loss of lubricating oil from the inside.

Crank Case as Engine Support. In practically all designs, manufacturers use the crank case as the support for mounting the engine and on which the other parts of the engine are mounted or supported. The actual engine suspension brackets may or may not be on the crank case.

The crank shaft is carried in the crank case on cross members, ribs, or bridging. The flywheel housing is mounted on the crank case at the rear. The timing gear housing is mounted on the crank case at the front. The cylinder block, if not an integral part of the crank case, is mounted on the top surface of it and the engine pan or oil sump is attached to its base. Naturally the design of the crank case must be such as to insure sufficient strength for rigidity.

The crank case receives a great variety of thrusts and strains. The power developed by the engine is received by the crank shaft and this important unit must be maintained in line irrespective of the road or load condition. Inspection of the crank case will show that it is well reinforced by its cross members as well as by its box-like design.

Constructional Features and Metals. Fig. 1 shows the Pontiac eight-in-line engine on the assembly line. It will be noted that the crank case and cylinder block are cast as one

unit. When cast as one unit, the usual practice is to make the casting from a high grade of grey iron. At times, builders have used lynite casting for the crank case and have inserted sleeves of cast grey iron for the cylinder bores.

Owing to the fact that excessive weight in the engine leads to higher production costs and higher operating costs, manufacturers have used aluminum for the crank case in many instances. Fig. 2 shows the Packard eight-cylinder power plant

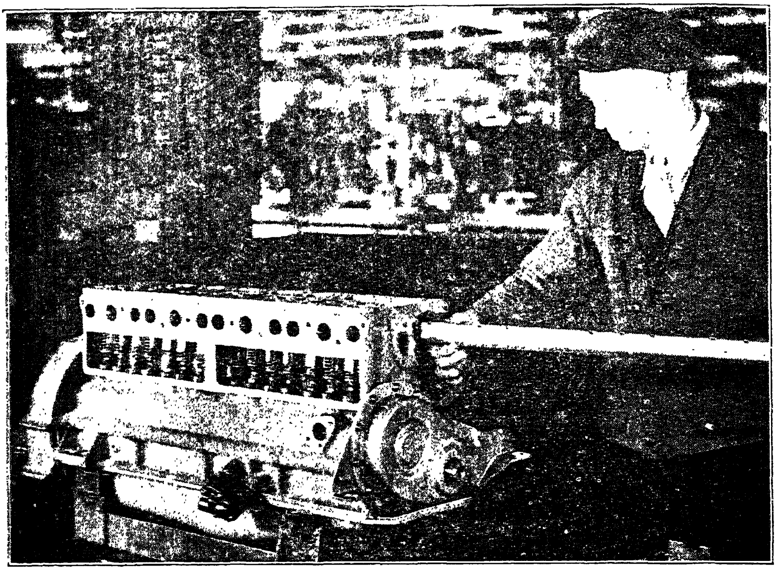


Fig. 1. Pontiac 8-Cylinder Engine on Assembly Line

in which the crank case is cast from aluminum. The cylinder block is constructed separately and attached to the crank case by means of studs. In all cases the cylinder bores are made from cast grey iron.

Experiments are being conducted, looking toward the adoption of metals which will give longer wear for cylinder bores, but the use of aluminum in this work is not practical. The use of aluminum for crank cases, flywheel housings, timing-gear housings, and in some instances for the transmission cases and oil sumps and engine pans, does much to decrease the

weight of the power plant. As the weight of the power plant is decreased, it is possible to decrease the weight of the car frame, axles, and other units, so that the saving made in weight by the use of aluminum in cases of engine parts is real economy all along the line.

Engine Suspension. There has always been a discussion as to the relative merits of the two popular forms of engine suspension. These are the three-point and the four-point suspension. With the adoption of rigid frames and rubber mount-

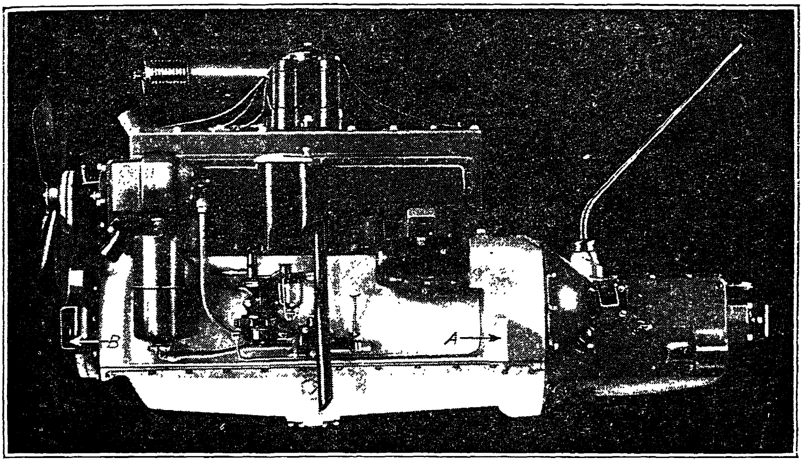


Fig. 2 Packard 8-Cylinder Engine

ings for engines, the four-point suspension of one or another form has been widely adopted.

Four-point suspension is illustrated very well in the case of the Packard engine, Fig. 2. *A* indicates one of the two forward supports and *B* indicates one of the two rear supports.

The general design of the automobile has much to do with the determination of the type of engine suspension. Where four-point suspension is used, the engine crank case is depended upon to add rigidity to the frame as the crank case itself acts as a member of the frame in strengthening it and preventing distortion or twist. Where three-point suspension

is used, the car is free of distortion around the engine, without any tendency to distort the engine crank case.

Rubber Mounting for Engine Suspension. It is known that it is practically impossible to remove all vibration from engines. The noise set up within the engine from the action of the moving parts is certain to result in some form of vibration and this in turn induces noises which are transmitted to the car frame and car body.

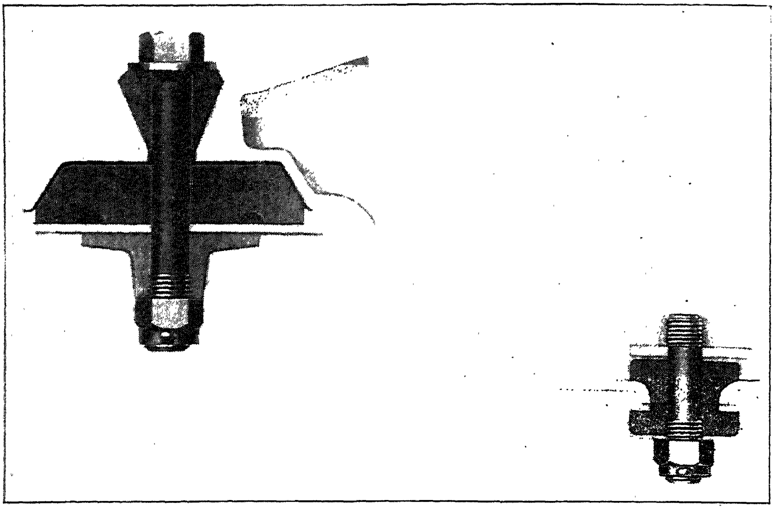


Fig. 3. Sectional View of Rubber Engine Mountings of Oldsmobile
The shaded portions indicate the rubber cones between engine and frame.

The introduction of rubber mountings, such as those illustrated in Fig. 3, has done a great deal to prevent disagreeable vibration and noises reaching the ears of the driver and passengers of the car. Rubber mountings are made in a great variety of forms, the principle being the same in all cases. The flexible and vibration absorbing rubber is introduced in some form between the engine supports and the engine mounting brackets of the car frame. The Ford Model A uses a spring suspension on the front cross member. This method has been used in quite a number of cars. In most instances the rubber mounting is used to afford the means of absorbing vibrations

which are certain to result in noises if transmitted to the car frame and car body.

ENGINE MOUNTINGS

Chrysler Motors Floating Power. The term "floating power" is given to a certain type of engine-to-frame attachment, which has been designed to eliminate all sense of vibration from frame and body. Floating power is a revolutionary but very satisfactory method of slinging the engine in the frame.

In the conventional type of engine-to-frame attachments, the engine is supported on the front cross member of the frame at the front and on the side frame members at the rear in the case of the three-point suspension or entirely on the side frame members in the case of the four-point suspension. In both the above types of attachments, it will be seen that most of the weight of the engine is above the points of attachment. In more recent cars, the supporting points have been encased in rubber to absorb vibration.

When the piston is going down on the power stroke, the movement of the car, because of its weight, sets up a resistance through the wheels, propeller shaft, crank shaft, and angle of the connecting rod, which causes the piston to press with considerable force against the right-hand side of the cylinder. This pressure in the cylinder tends to rotate the engine support against the car frame and, as the explosion and piston-to-cylinder-wall pressures come rapidly rather than continuously, a vibration is felt throughout the car. If the engine supports were taken away, this torque reaction would tend to rotate the engine around the crank shaft and, as the weight is all above the axis of revolution, this tendency would be accentuated and unbalanced.

In the application of floating power—Fig. 4 shows the original design—there are two points of suspension only. One is at the front of the engine somewhere near the top of the cylinder block, the other is at the rear of the transmission. If a line is drawn from the center of the front support

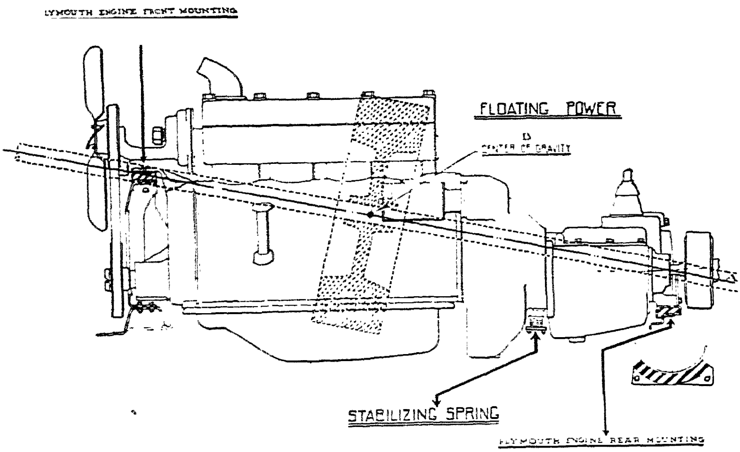


Fig. 4. Principle of Floating Power as First Applied to Chrysler Motors Products

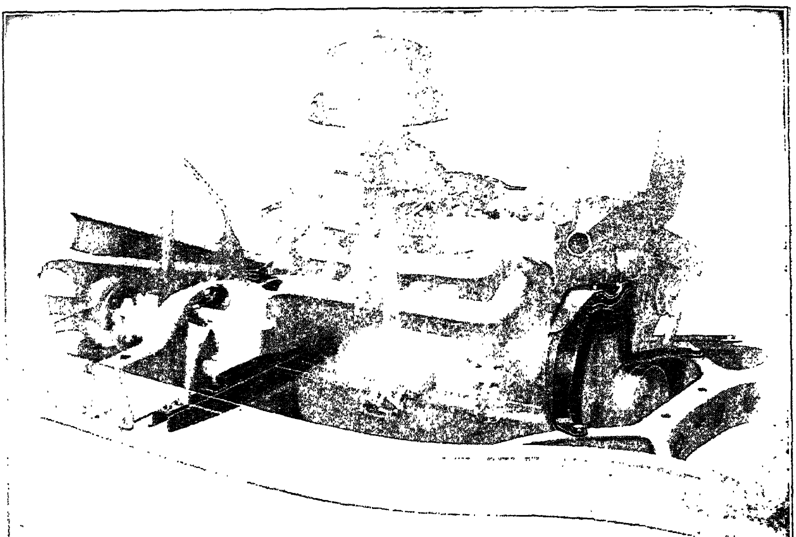


Fig. 5. An Application of Floating Power to a Chrysler Motors Power Plant

through the engine to the center of the rear support, as in Fig. 4, it would be found that the weight of the engine is equally distributed around this natural rocking axis and the engine would be in balance at any point of revolution just as a flywheel is in balance, so that if the floating power supports were actually bearings, the engine would revolve freely in them and continue to do so as long as power was developed in the cylinders. The floating power supports are insulated with rubber bonded to steel, and so made that they absorb this movement of the engine or torque reaction.

A short cantilever spring, in the case of the original design, extended from the rear of the engine to the right-hand side frame member, which maintained the position of the engine within the limits of the rubber mounting and preserved the alignment of the engine. The frame end of the spring was encased in rubber. Very little load was placed on this spring, its purpose being really that of a stabilizer. In later designs, Fig. 5, this spring was eliminated, the rubber mounting being used to absorb the tendency to rock.

When the power impulses in the cylinder set up this rocking motion, the engine swings to the right and this motion continues until there is sufficient tension or energy in the rubber supports to return the engine to its normal position, or to the left. Actually, this rocking motion to the right or left is continuous but is comparatively slow. This slow motion sets up a low frequency vibration which is inaudible and cannot be felt by anyone sitting in the car.

To further remove any chance of vibration, all metal connections between engine, frame, and body are eliminated. Clutch pedals, through which vibration is often felt, are mounted on a bracket attached to the side frame member. To prevent any end movement of the engine, an abutment member is placed at the rear end of the transmission.

Chevrolet "Six" Four-Point Engine Mounting. The four-point Chevrolet "Six" engine mounting is novel in that the four points utilized are not the conventional four points long popular with motor car manufacturers. When consulting the

diagrammatical illustration, Fig. 6, it will be noted that these four points are: first, the central point on the forward cross member of the frame; next, the central mounting point at the rear of the transmission on the cross member; and then, two shock absorbing or buffing members located at the right and left sides of the engine as indicated by the heavy dotted line running transverse the diagram.

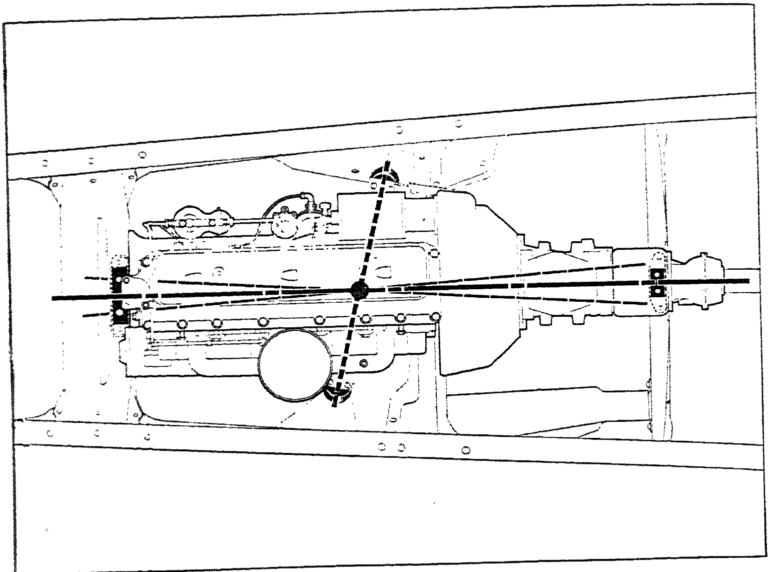


Fig. 6. Chevrolet Six Four-Point Engine Mounting

A study of the diagram will show that the dark circular dot in the center of the power plant mass (center of gravity) is the point at which the several lines extended from the four points meet or intersect. Note also that no crank-case arms are extended from the rear of the crank case but rather that the rubber mounting blocks at either side of the engine are utilized to absorb the tendency to rotate, created by the torque reaction of the engine under power. The rubber blocks permit of a certain amount of rotation, then absorb the rotative effort, giving it back to the engine, so that vibration is dampened out.

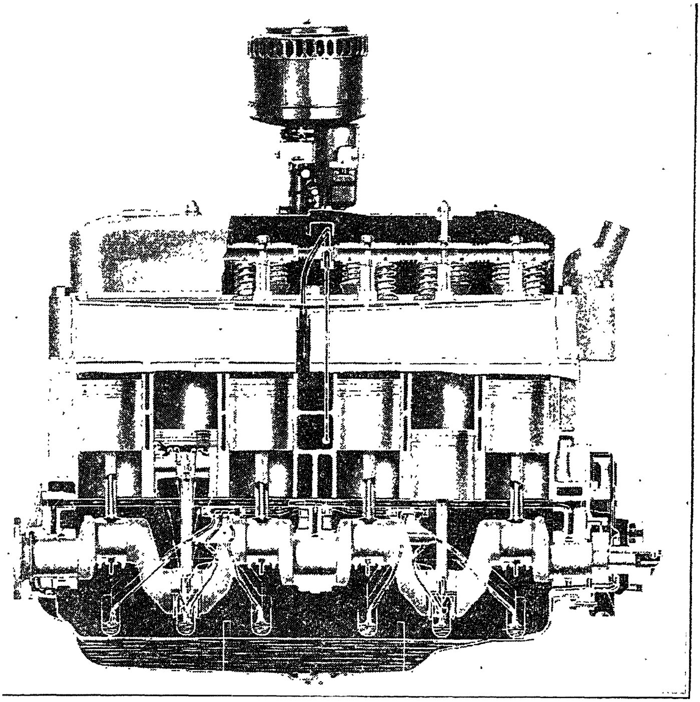


Fig. 7. Chevrolet Truck Engine Lubricating System with Oil Sump at Bottom of Pan
Note tubes supplying oil and the six oil dipper troughs.

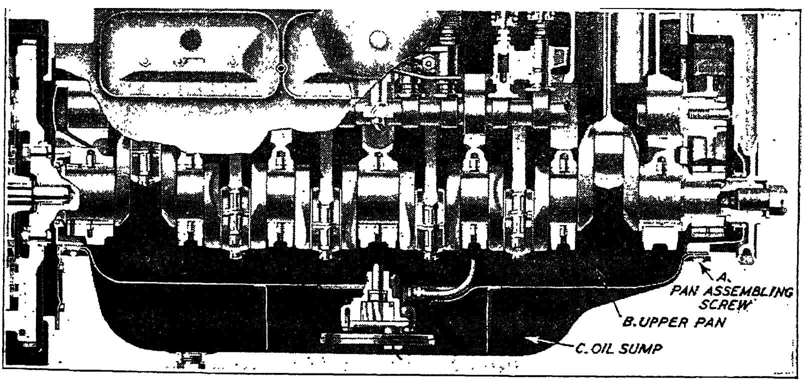


Fig. 8. Pan and Oil Sump for Full Pressure Lubrication. A—Pan Assembling Screws; B—Upper Pan; C—Oil Sump
The upper level of the pan is used to catch the oil thrown from the bearings to turn it back into the oil sump, which is the outer pan.

Engine Pans and Oil Sumps. As a rule, the engine pan and oil sump is a single unit and is bolted to the lower surface of the crank case. Fig. 7 illustrates a pressed-steel engine pan and oil sump. It will be noted that there are six troughs in this assembly. These troughs are in what is called the upper level of the engine pan. When splash lubrication is depended upon, each connecting rod is provided with a trough. Oil is lifted to these troughs and splashed by a dipper to the connecting rod, connecting-rod bearing, cylinder bores, pistons, cam shaft, valve lifters, etc.

In practically every instance, two levels are provided. Only in those designs where splash lubrication is used are the grooves provided. Where force-feed or full force-feed lubrication is used, the upper level consists of a plain pan without oil troughs. It acts simply as a splash reducer and is provided with screens through which the oil may return to the lower level or the sump. In fact, some manufacturers employ a large screen for use in the upper level.

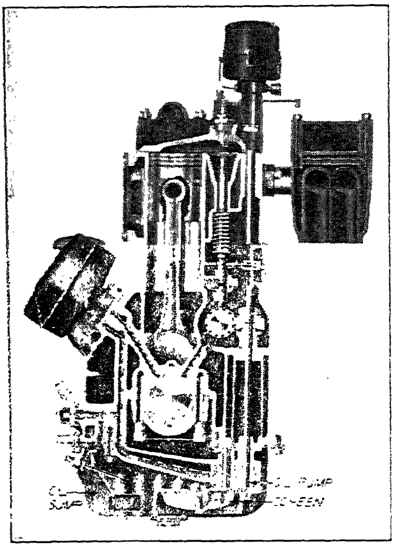


Fig. 9. Transverse View of an Engine Oiling System

Fig. 8 illustrates a very common practice in the construction of engines where pressure or force-feed lubrication is used. It will be noted that the assembly consists of an inner pan and an outer pan. The inner pan is what might be termed the upper level, and the outer pan carries the oil and is termed the oil sump.

Fig. 9 shows a conventional pressure oiling system. The oil is carried in the sump, pumped through the screen, and forced by the gear pump to the oil lines.

Repairing Damaged Crank Case by Patching. Fig. 10

illustrates the result of a poor job of connecting-rod adjusting. The man who did the repair work did not install the cotter keys in the connecting-rod bolts, with the result that the bearing loosened and a connecting-rod bolt nut dropped off. When this happened, the rod went through the crank case with the result shown.

It sometimes happens that in a wreck of this kind, the damage is so great that it is impossible to repair it satisfactorily, except that welding be resorted to. Owing to the fact that the connecting rods always fall between the bridging (cross ribs) in the crank case which supports the main bear-

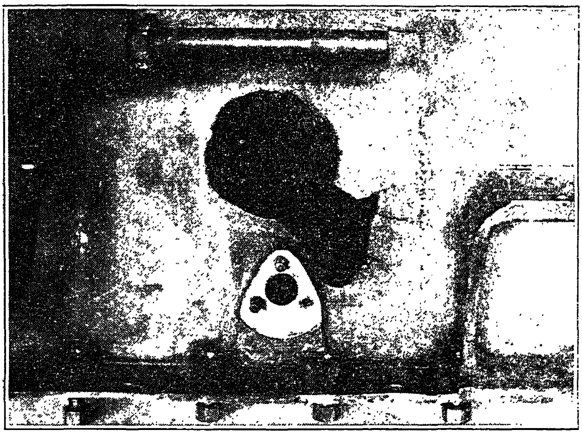


Fig. 10. Crank Case Damaged by Thrown Connecting Rod

ing, it not infrequently happens that a rod will go through the crank case, Fig. 10, without doing any particular damage to the case outside of knocking a hole through the side. In other words, the strength of the crank case is not seriously impaired. A repair which will seal the crank case against the loss of lubricating oil is all that is needed in such an instance. Fig. 11 illustrates the first step in making a repair where an accident of this general type has occurred.

It will be noted that the mechanic has laid out a rectangular section around the hole knocked into the crank case by the connecting rod. He has then cut out, by means of a hack

saw and chisel, the broken parts which may be noticed on the top of the bench. A file is used to round up the edges of the metal.

The next step is to provide a steel plate about 1/8 inch thick and of sufficient size to lap over the edges of the squared hole. The steel patch is laid off and drilled for 1/4-inch holes 1 1/4 inches apart. The patch is then held in position and a punch is used to mark through several of the holes so as to drill the crank case with a 3/16-inch drill. These holes are then tapped with a 1/4-inch U.S.S. tap, Fig. 12. The next point is to run in several of the screws to fasten the patch in position temporarily. The

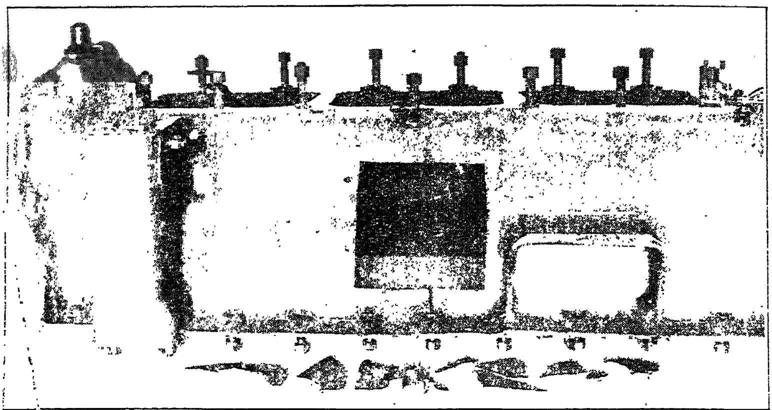


Fig. 11. A Crank Case Ready for Application of a Patch

center punch is then used again and the crank case is marked for each of the drill holes desired, after which the holes are drilled and tapped. When this part of the repair work is completed, the patch is removed and a gasket made. This gasket is made from "vellumoid," heavy paper, or other good gasket material. A little shellac is applied to each side of the gasket and to the crank-case edges and on the patch. When this has become tacky, the patch is placed in position and the round head machine screws or cap screws which are to be used for holding it in position are run home.

While a patch of this kind does not restore the crank case

to its original strength, it does add materially to the strength and will be found quite satisfactory where the cross bridging of the crank case has not been harmed by the original accident.

Repairing Damaged Crank Case by Welding. When cars are in wrecks, it very frequently happens that the crank-case arms or engine supports are broken off. If these have been cast integral with the crank case, it means that welding will usually have to be resorted to in order to secure a first-class job. The oxyacetylene method is the usual process in this type of work.

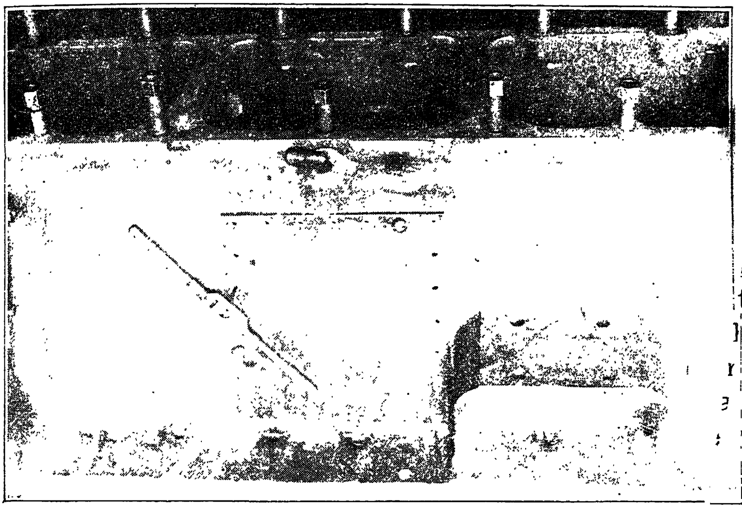


Fig. 12. Patch Made from ⅛-Inch Sheet Steel and Drilled for Cap Screws or Machine Screws
The crank case is being tapped for the application of the patch.

In many cases, the welding is done without removing the engine from the car frame.

Bronze welding is being used more and more each year as a repair process for welding crank-case fractures, engine arm supports, and even cylinder blocks, without resorting to preheating.

LUBRICANTS AND TESTS

Oils. Practically all the oil used in automobile, tractor, and truck lubrication is a mineral oil. Racing cars may use castor

oil. Oils are known according to the base from which they are refined. The eastern oil is refined from a paraffin base oil. These oils are generally known as Pennsylvania oils. The western oils are refined from a base known as asphaltum. This refers to the crude oil as it comes from the wells. Generally speaking, the eastern oil has a higher flash test and the western oil a lower pour or cold test.

After many years, the Society of Automotive Engineers has persuaded the oil refiners to label their oils with numbers to indicate the grade of oil. These numbers indicate the viscosity of the oil. Most cars use a No. 40 oil for summer use or general all-round driving. Some cars which use a No. 40 oil, which might possibly be termed a medium oil, will use a No. 30 or medium light oil for winter driving. Other cars will use a No. 20 or light oil for winter driving and a No. 40 for summer. The higher the number, the heavier the oil. Air-cooled engines, of course, use an oil of a heavier body.

Oil Tests. The garage man is interested in some simple tests which he can use on oils in order to verify claims made by agents. Generally speaking, it is not desirable to attempt to conduct an elaborate series of tests. In fact, the equipment required for the elaborate tests would be entirely too expensive. The safest guide, of course, when buying oils, is to buy from reputable companies—companies which have too high an investment in equipment and good will to risk turning out a poor product. However, the following tests will enable the garage man to determine, to a certain extent, some of the outstanding characteristics of the oil which he may be using.

Pour Test. It is very likely true that more damage occurs to engines owing to the fact that the oil does not have a low enough pour test than to the fact that the oil does not have a high enough flash or fire test.

The easiest way to check on the flow qualities of an oil under extremely low temperatures is to put a quantity of the oil in question in a flat vessel and place it on the outside of the building where it will be chilled. If a laboratory thermometer is handy, it should be placed in the oil being tested. As the oil

chills, the reading of the thermometer will correspond. The lowest point at which the oil will still flow should be noted. It is then possible to know just what is happening in the crank case of the engine serviced with this oil at low temperatures. Some very good oils will "jell" at low temperatures so that it would be impossible to force them through the lubricating system of an engine.

One of the foremost motor car builders recommends that a pint of kerosene be placed in each gallon of oil that is recommended for summer use if this same oil is to be used in the winter when the temperature gets down to zero. This is to insure the oil flowing and prevent damage to the engine before it is thoroughly warmed.

Flash or Fire Test. If the garage owner desires to test the oil for flash or fire, he should place a small quantity in an open vessel and proceed to heat the oil until it starts to smoke. A thermometer should be in the oil so that the temperature may be read. This will be a special thermometer, reading to approximately 500° Fahrenheit. Ordinarily the oil will start smoking somewhere between 300° and 400°, so that if a lighted match is passed over the oil, a flash will occur as the vaporized oil is burned. The instant the oil reaches this point, the reading on the thermometer should be taken. This is termed the flash point.

The fire test is made in a similar manner, the only difference being that the oil should be heated to such a point that it will continue to burn after flashing. This point will usually be found 30 to 50 degrees above the flash test reading.

Acid in Oil. Owing to the fact that much oil is refined by the use of acid, it is not a bad point to check on the oil to see whether there are traces of acid within it. If sulphuric acid is in the oil, it will be found that it will attack the metals of the engine, discoloring them and in some cases causing them to be etched or eaten away. Litmus paper is the usual method of testing. This paper may be purchased from the drug store. A strip is dipped into the oil; if acid is present, the paper will turn red.

Viscosity Test. As a rule, the garage man will not be interested in purchasing the equipment which would be necessary to make a viscosity test. When making a viscosity test, the oil engineer heats the oil to a certain predetermined temperature. He then allows it to flow through an opening, having a fixed size. The amount of time required by the oil to flow through this opening, at the predetermined temperature, is used in computing the viscosity of the oil. It will be seen that the viscosity of the oil has a very definite bearing on the ability of the oil pump to force the lubricating oil through the lubricating system in a satisfactory manner. The effects of light oils or heavy oils upon the pump pressure will likewise be readily understood. When oils are cold, they flow less readily and the pump in attempting to force them through develops considerably more pressure than when the same oil is hot. This extra pressure is registered on the oil gauge. It is always a good plan to consult the car manufacturer's recommendations when purchasing oil for any particular make of car or when purchasing a stock of oil for servicing cars. In case a general service station or garage is being operated, the best plan in selecting the oils is to get in touch with the oil salesman and get the oil refineries' recommendations for oils for certain cars. These recommendations are printed in chart form, and four or five different grades of oils will ordinarily service all of the different cars.

Heavy responsibility rests upon the service man or garage man for servicing cars with the proper grade of oil. With the chart available, it is easily consulted and mistakes are not likely to happen. Perhaps the greatest service being rendered the automobile public today is seeing that the lubrication problems of their motor cars are properly solved and lubrication properly cared for.

LUBRICATION

Oil Indicators. The garage or service station man is often called upon to do quite a bit of educational work with reference to the lubrication of motor cars. Strange as it may seem, a

great many car owners feel that if they watch the hand of the oil pressure indicator on the instrument board, that is all the attention they need to give the oiling system. Such an indicator is shown at *B* in Fig. 13. The indicator shown at *H* is just as

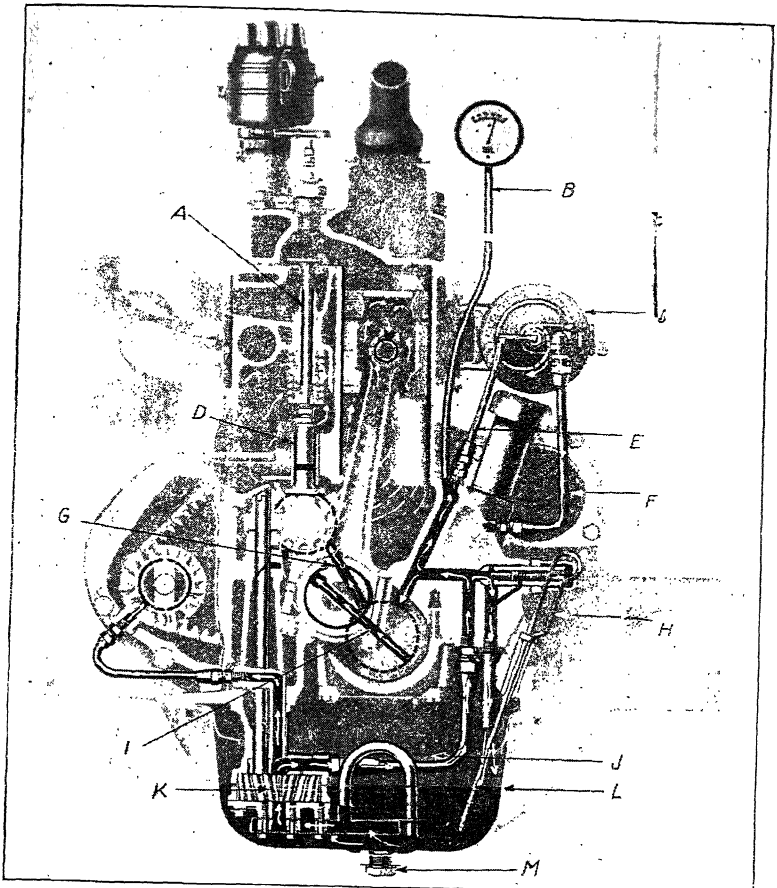


Fig. 13. Lubrication System Employed in Dodge Senior Six

important for it indicates the amount of oil in the oil sump, while *B* simply indicates that the oil is circulating or is not circulating.

The customer should be instructed not to permit the oil to drop to too low a level in the crank case. Generally speaking,

it is not safe to have the oil drop below the halfway point on the measuring gauge *H* in Fig. 13. The reason for this is that the greatest demand is placed on the lubricating system when the car is being driven over steep grades. Under these circumstances the oil may flow to the rear of the oil sump and if the oil pump is at the center or toward the front, the oil may drop away from it unless the sump is almost full. The owner may then come to the service station and say that he burned out a bearing in the car and still had plenty of oil.

Engine Lubrication. Fig. 13 illustrates what might be termed a standard form of lubrication. There are a number of variations from this particular form but they are of minor importance. The general plan in engine lubrication is to pour the oil into the engine crank case, where it flows into the oil sump, which is a lower level. In Fig. 13 the oil level is shown at *L*. The arrow at *J* indicates the upper pan level. This acts merely as a baffle plate to prevent oil splashing from the sump upward and to collect oil which is thrown out by the oiling system and turn it back into the oil sump. The black lines are used to indicate those surfaces which are oiled from the lubrication system. Two black lines will be noted at *A*, surrounding the valve stem. The oil gets on to the valve stem from a mist of oil formed as oil is forced through the lubricating system and thrown off at the ends of the connecting-rod bearings, as indicated at *G*. The same mist of oil which lubricates the top end of the connecting rod splashes on to the walls of the cylinder and the piston and thus lubricates them. This will be noticed in Fig. 13.

The oil pump shown at *K* in Fig. 13 is a gear-type pump similar to that shown in Fig. 20. It is driven from the cam shaft by means of gears. The pair of gears at *K* pick up the oil from the oil sump as shown by the arrows. Leaving the oil pump, the oil flows upward through the oil tube. The arrows indicate this path. A small portion of the oil will go over to the timing case to lubricate the timing chain and front-end bearings. The main supply will travel upward and be conducted by means of tubes to the main engine bearings. Figs. 14 and 15 illustrate

how tubes may be arranged to conduct this oil to the main engine bearings. When the oil is introduced to the engine main bearings, it lubricates the bearings and the excess amount flows through holes drilled in the crank shaft and through the throws of the crank shaft into the crank pins. The oil first lubricates the connecting-rod bearings and then the excess amount finds its way to the end of the bearings and is thrown outward and upward as the crank shaft rotates. Referring

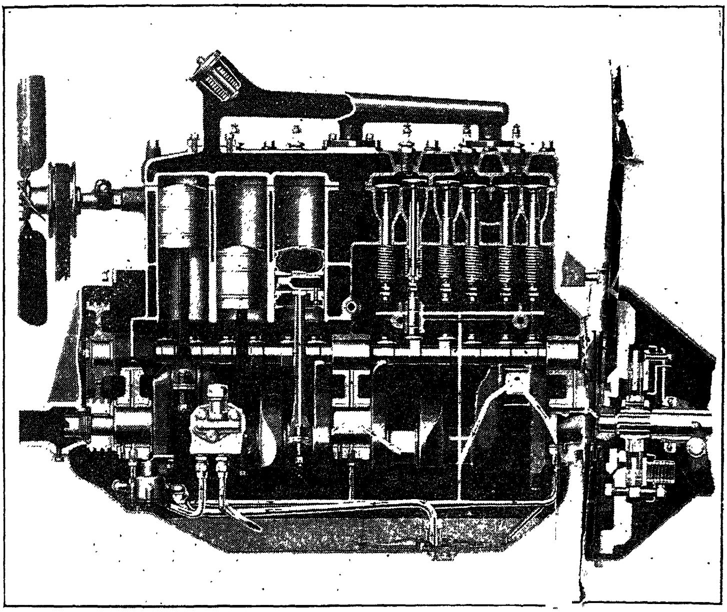


Fig. 14. Cutaway View of Engine in Which Full-Force-Feed System Is Employed

again to Fig. 13, it will be noted that the oil indicator or pressure gauge *B* is directly connected to the main oil line so that when pressure is generated by the oil pump it is indicated on the gauge.

Another feature is the oil strainer or the oil cleaner marked *C*. It will be noted that a certain amount of oil will find its way from the main supply line through the tube *E* to the cleaner *C* where it is circulated through the cleaning fabrics and overflows backward through the line *F* into the crank case.

Still another feature is the pressure relief. This is shown just back of the handle on the oil indicator *H*. It consists of a spring with an adjusting screw. As pressure builds up in the main lines, the plunger is forced back against the spring pressure and any excess oil is thus allowed to return to the crank case. This arrangement is termed a by-pass or pressure-relief valve.

All surfaces lubricated by the engine oil are indicated by black lines and the reader will do well to make a very careful

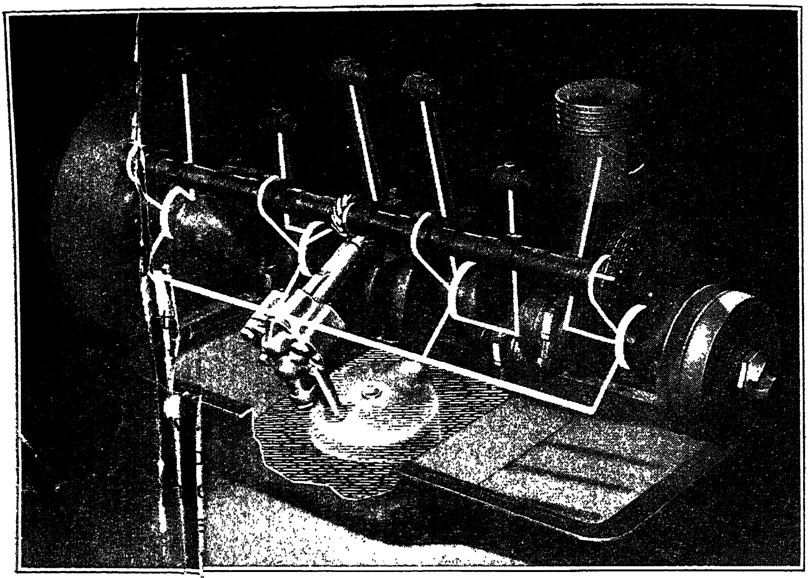


Fig. 15. The 1937 Oldsmobile Six Pressure Lubricating System
Courtesy of Olds Motor Works

study of this illustration in order to learn the various surfaces which are thus lubricated. The drain plug *M* is used when the crank case is to be drained.

Full-Force Feed Lubrication. The system illustrated in Fig. 13 is representative of most oiling systems. Fig. 14 shows a system of the type which is termed full-force feed. In the case of Fig. 13, the piston pin is not oiled under pressure. The piston pins in Fig. 14 are lubricated under pressure, from the connecting-rod bearings. It will be noted that rod No. 3, which

is shown in section, has a white line running from the connecting-rod bearing to the piston pin. A very small arrow indicates the flow of oil along this white line. Oil reaching the piston pin lubricates the piston pin and then flows out along the pin on to the cylinder wall, from which point it lubricates the cylinder wall, piston surfaces, and piston rings. The flow of oil in Fig. 14 is indicated by the white lines and arrows.

The oil picked up from the oil sump is passed through a strainer and goes to a pump at the forward end of the engine and from this point is pumped to the engine main bearings. As indicated by the arrows, the oil then flows from the main engine bearings to the connecting-rod bearings, from which point it is forced to the piston-pin bearings. The valve lifters are lubricated by oil which is sent through a line to the valve-lifter guides. This is shown for the rear half of the engine.

Force-Feed or Pressure Lubrication. The system illustrated in Fig. 14 and also in Fig. 15 is of the type termed force-feed or pressure. The main difference between these two systems and the one shown in Fig. 13 is the lack of forced lubrication to the piston pin. Another point in which there is variation is force-feed lubrication to the cam-shaft bearings. Fig. 15 shows forced lubrication to these points through drill holes from the main engine bearings. This feature is not always incorporated in force-feed systems. It is incorporated in the one shown in Fig. 13.

Splash-and-Circulating Lubrication. For many years the splash-and-circulating lubrication was one of the most popular forms of automobile engine lubrication. No particular fault has ever been found with it except in cases of high-speed engines. Where extremely high speed is used, some engineers question its ability to perform properly. The principles of this system of lubrication are illustrated in Fig. 16.

Ford Model "A" Engine Lubrication. For many years Ford used the splash-and-circulating system in the Model "T" engine. Oil was lifted by the magneto magnets on the flywheel assembly and thrown into the top of the transmission cover. As it dropped down, a certain amount fell into the funnel-like

arrangement on the rear end of the oil line. Then from this point it flowed forward through the slanting oil line to the timing-gear case, where it first oiled the timing gears and the surplus found its way backward over the oil pan and there

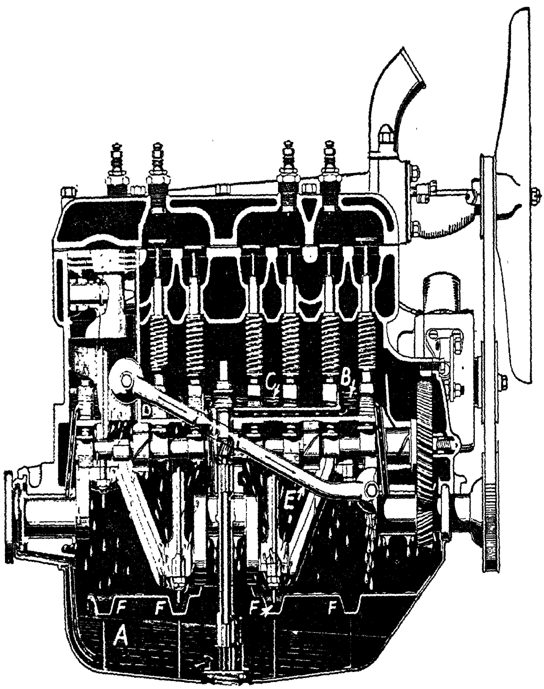


Fig. 16. Ford Model "A" Oiling System Is of Splash-and-Circulating Type
Oil is sent from the lower sump A to the upper level B, from which it flows to level C, to level D through the tube E to the pan and troughs F F F F, from which point it is splashed by the dippers on the rods.

filled the four troughs. The connecting rods, dipping into these troughs, splashed the oil upward and lubricated the engine.

Somewhat the same idea has been followed out in the Model "A" engine. It will be noted in Fig. 16 that oil from the oil sump A is lifted by the oil pump gears and forced upward along the central vertical tubes, from which point it flows forward through a small passageway to the oil level marked B.

A small cross rib at the rear of the point *B* serves as the forward oil level in the valve compartment. Oil overflowing this point then passes to the oil level *C*. After overflowing the rib at the rear of the oil level *C*, it fills in a new oil level at the point marked *D*. Reaching a certain level at this point, the surplus oil then flows through the oil tube exposed on the outside of the engine and on forward to the front of the engine, where it is turned back into the upper level of the oil pan. Oil flowing from this point fills the four troughs marked *F*. Oil splashed from the oil troughs serves to lubricate the connecting rods, the pistons, and cylinder walls. Oil flowing from the upper levels *B*, *C*, and *D* passes through drilled openings or tubes to the three main engine bearings, as will be noted from a study of Fig. 16. Oil also flows from these upper levels to the cam-shaft bearings and lubricates them. Surplus oil coming from the rear main bearings is caught by oil slingers and carried through an opening back into the oil sump. Excess oil from the timing gears and front crank-shaft bearings finds its way into the sump also. This system belongs to the splash-and-circulating type. It has no counterpart in any other engine inasmuch as no other engine makes use of the valve compartment as an oil reservoir from which the bearings are fed.

CHEVROLET "SIX" OILING SYSTEM

In the Chevrolet oiling system, the vane type oil pump, driven indirectly by the cam-shaft, is placed inside the crank case. The oil pump sucks the oil, through a screen, from the bottom of the oil pan and delivers it, under pressure, to the center main and center cam-shaft bearings and through distributing pipes to the front and rear main and cam-shaft bearings. See Fig. 17.

The pump also delivers oil to the oil distributor on the left side of the motor, where the flow is divided and passes through pipes to the oil troughs, located under each connecting rod bearing.

The oil dippers on the ends of the connecting rods lift the oil and a portion of it is forced up into the connecting rod bear-

ings. The rest is broken into a fine spray or oil mist, which penetrates to all moving parts of the motor, lubricating them.

From the high pressure side of the oil distributor, a connection leads to the pressure gauge on the instrument panel, to indicate oil pressure at this point. The rapid action of the rocker arm adjusting screw in the oil-filled socket throws a mist of oil over all of the valve mechanism, including the valve stems. The excess oil which may overflow from the rocker shafts is returned to the crank case through a telescoping tube.

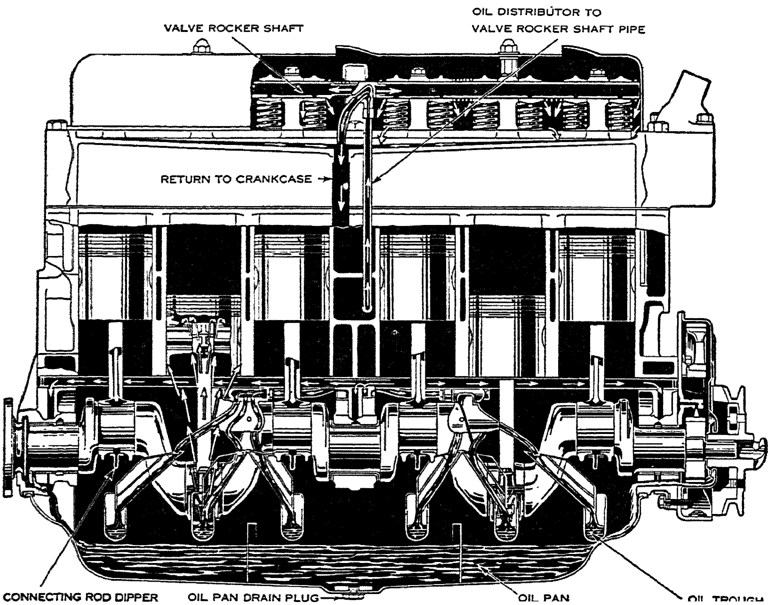


Fig. 17. Chevrolet Engine Lubricating System

MAINTENANCE LUBRICATION OF THE FORD "V-8"

The care with which maintenance lubrication service is periodically given to any automobile determines in a large measure the life of the automobile. In the case of the Ford "V-8," Fig. 18, it is recommended that those points indicated on the lubrication chart under the title, "Each 1000 Miles," receive careful attention at those periods and that each 5000 miles, or twice yearly, those other points at the bottom of the

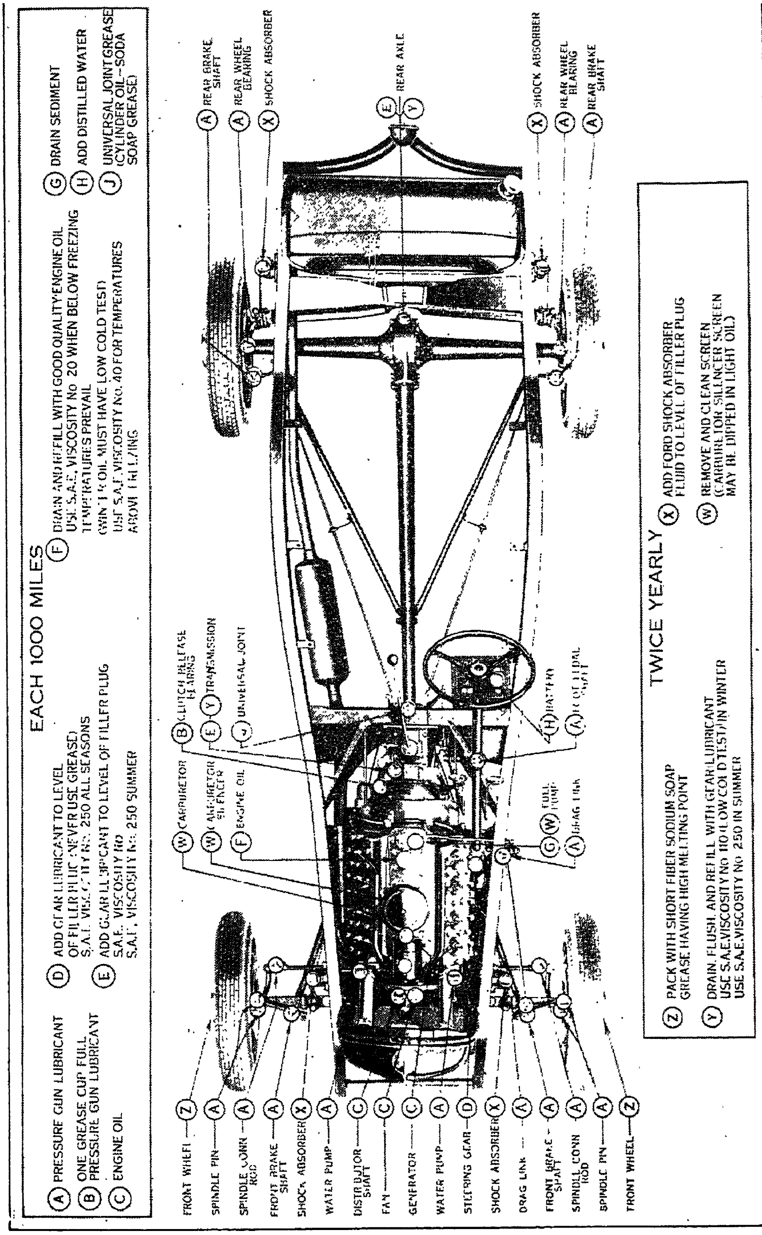


Fig. 18. Ford "V-8" Lubricating Chart

lubrication chart, under the caption, "Twice Yearly," be given attention.

The new Ford "V-8" should have the oil drained after 300 miles and then each 1000 miles thereafter. Have the engine warm in order that the oil will drain more completely. The proper amount of oil is five quarts and the proper viscosity is S.A.E.40 for summer use and S.A.E.20 for winter use. It

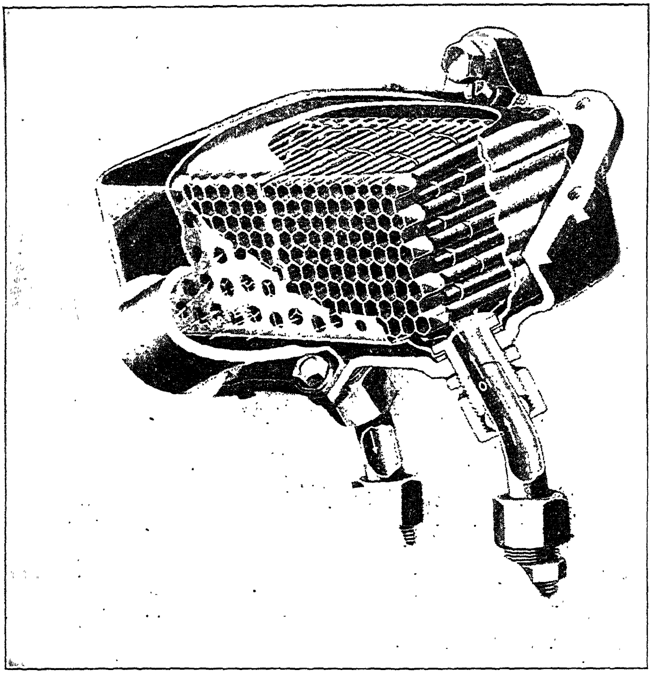


Fig. 19. Buick Engine Oil Temperature Regulator

is very important that the winter oil have a low cold test. By this is meant that the oil should pour at a low temperature.

A study of the lubrication chart will show points requiring lubrication each 1000 and 5000 miles.

Engine Oil Temperature Regulator. Engine oil should be neither too hot nor too cold if it is to be of best service. In order to secure a rapid warming up of the oil in the winter time and a prevention of undue temperatures on hot summer days, a

simple oil regulator is provided on many automobiles. The nature of this device is illustrated in Fig. 19, where it will be seen that it is nothing more nor less than a honeycomb type of radiator enclosed in an iron or other metallic housing. Instead of the air passing through the radiator core, the water from the engine is passed through the core and the oil is circulated in the position ordinarily occupied by water in the cooling radiator, that is, through the passageways as shown in the illustration.

When the oil is forced through these passageways around the cells or tubes of the radiator, it is in heat contact with the water which is coming from the engine. In the winter time, the water within the engine jacket is quickly warmed and as

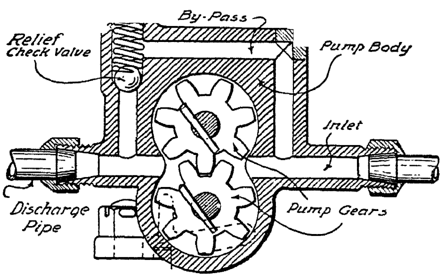


Fig. 20. Gear-Type Oil Pump in Section, Showing Principles of Operation

it passes through the oil radiator core it imparts heat to the oil. This makes for fluidity of the oil so that it will go to every part of the engine requiring lubrication.

In the summer time when the oil temperature is likely to get above the proper operating point, the same action results in cooling the oil down to a point where there is no danger of it permitting bearings to be burned out. It will be seen, too, that the device is more than a mere oil cooler inasmuch as it heats the oil in the winter time as well as cooling it in the summer time, thus regulating the temperature at all times.

OIL PUMPS

Gear Pumps. There are two types of oil pumps popularly accepted and used by engineers. The one meeting with widest

acceptance is the gear-type pump. Figs. 20 and 21 illustrate several of these. The principles of the gear-type pump are illustrated most clearly in Fig. 20. It will be noted that oil entering from the inlet tube finds its way round the gears, being carried between the gear teeth and the pump wall. Arriving at the opposite side from which it enters, it is discharged through the discharge pipe. It is prevented from returning through the inlet pipe by the contact of the gear teeth at the center of the pump. An overload of oil will find its way through the relief

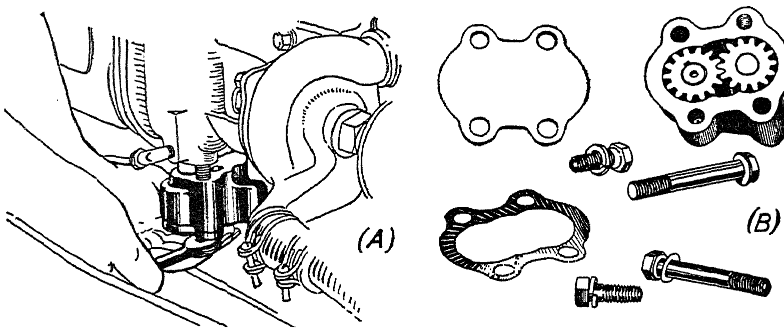


Fig. 21. A—Removing a Gear Type Oil Pump; B—The Gear Type Pump Disassembled

check valve and the by-pass, back through the body of the pump into the inlet tube. The pressure within the oiling system is thus controlled by the spring pressure in the relief valve. The oil pump, shown in Fig. 21, operates on the same principle as the one shown in Fig. 20. The throttle control is used in order to increase the amount of oil going to the system under high speeds.

The oil pump gears are enclosed in a housing which fits closely around the outside of the gears. The cover of the pump fits closely to the sides of the gears, with a gasket between the mating surfaces. Care should be taken to see that a gasket of the correct thickness is used. The disassembled view of the gear type pump shows this gasket as well as cover and housing.

Vane-Type Pump. The vane-type pump, Fig. 22, operates on a rather simple principle. The large gear shown is on the crank shaft or on the cam shaft of the engine. As it turns, it

drives the small gear which, in turn, turns the head of the pump. This head is illustrated at A. In the head of the pump a groove has been machined and in this groove are two vanes. These vanes are free to move forth and back in the slot provided in the head. They are held in contact with the body of the pump by a small spring between the inner ends of the vanes. The assembled view shows that oil may be drawn in through the inlet B and is then carried ahead of either of the vanes and thrown out through the outlet C. The action of the vanes is an eccentric one and the farther the vane is turned from the inlet B toward the outlet C, the smaller the area between the head of the pump and the side wall or body of the pump. These pumps will not develop a great deal of pressure although they will throw considerable quantities of oil.

CRANK-CASE DILUTION

When the gasoline used in automobile engines was of a very high grade, complete vaporization was comparatively easy. Demands placed upon oil producers and refiners led to the development of what is termed the heavy grades of gasoline. The gasolines produced today for automobile use are a combination of the lighter ends and heavier ends. The greatest objection to their use lies in the crank-case dilution. New methods of cracking and of refining gasoline have been developed.

Crank-case dilution, as every owner knows, refers to the fact that raw gasoline passes the piston assembly and thus finds its way into the crank case, where it dilutes the oil. This dilution or thinning of the oil results in the loss of some of the lubricating qualities of the oil.

When the gasoline combines with the oil in the crank case, it destroys the viscosity of the oil. The oil is permitted to break down under load and this results in thinning it out until metal parts may come into contact with each other. Ideal engine lubrication is secured only when there is a considerable film of oil between all moving parts. These moving parts, whether they be the pistons sliding within the cylinders or

the crank shaft rotating within its bearings, are moving over a film of oil rather than over other metal parts. When the crank-case dilution reaches the point where the oil breaks down and permits metal to metal contact, damage to the parts concerned is very rapid.

There are other elements or features connected with crank-case dilution. These have to do with the fact that certain

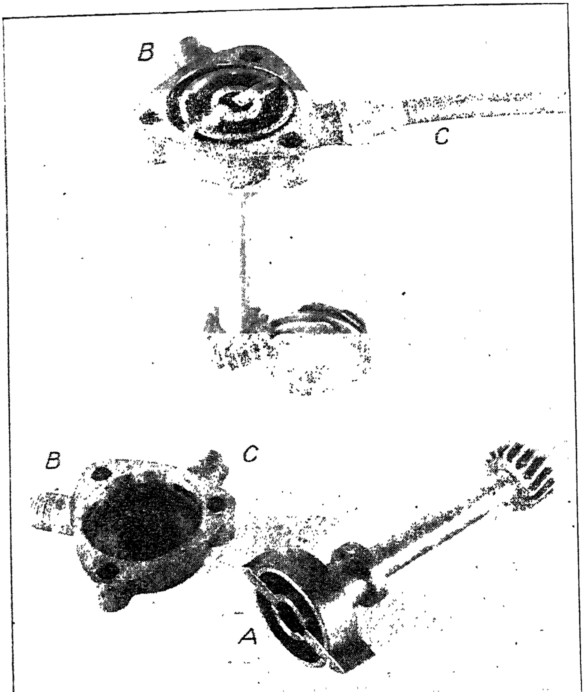


Fig. 22. Disassembled and Assembled View of Vane-Type Pump for Automotive Application

substances within the gasoline, when combined with certain elements within the crank case, produce an acid condition with the result that the metal parts in the crank case in time become etched or eaten away. This is not always the condition but one which is likely to arise with crank-case dilution.

Still another feature which results in contamination of the lubricating oil is the possibility of road dust and water becom-

ing mixed with the lubricating oil. If this condition occurs, sludge will be formed. Sludge is formed by the mixture of small quantities of very fine dust, water, and oil. When a real sludge has been developed in the crank case, it has somewhat the appearance of dissolved soap, black in appearance and gummy in consistency. It is difficult to dissolve and remove and must be washed out with gasoline or kerosene. Sludge not only forms

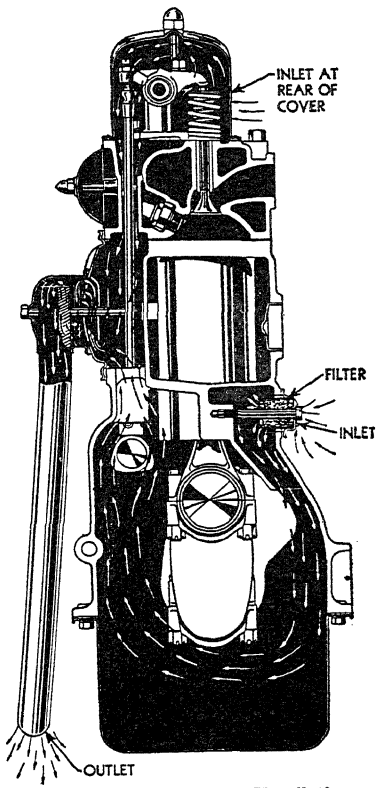


Fig. 23. Buick Crank-case Ventilating System
Courtesy of Buick Motor Company

on the inside of the crank-case walls but also in the oil pipes and oil passages in the crankshaft. If allowed to accumulate to a large amount, the flow of oil through the oil pipes and oil passages will be restricted, with consequent damage to moving

parts because of lack of adequate lubrication. It is likely to foam and froth.

CRANK-CASE VENTILATION

Owing to the fact that the heat developed within the crank case together with the crank-case dilution has a tendency to develop a condition which is bad for lubrication, engineers have designed and in many cases are applying crank-case ventilating devices. One of these is illustrated in Fig. 23. The purpose of

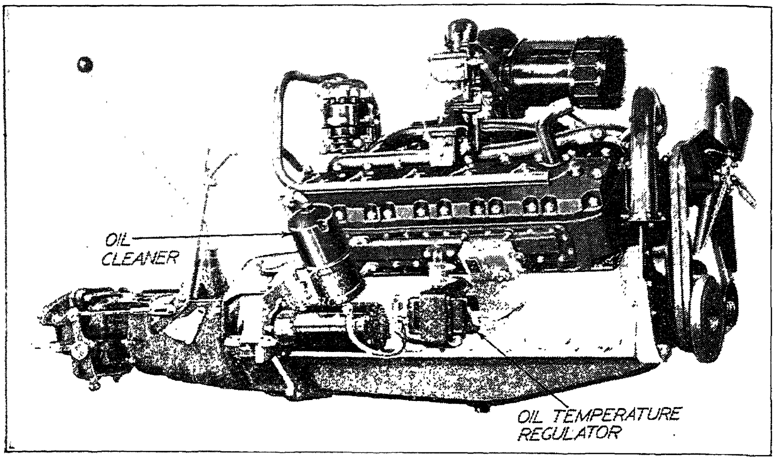


Fig. 24. Pierce-Arrow 12-Cylinder 175-Horsepower Engine, Showing Oil Cleaner and Oil Temperature Regulator

the crank-case ventilator is to see that fresh currents of clean air are passing through the ventilating device in such fashion as to draw off the vapors rising within the crank case. A study of the illustration will show how this is done. Where crank-case ventilators are used, the oil consumption is somewhat in excess of that where they are not in use. On the other hand, the amount of oil used is not excessive and the length of care-free service given by the engine is increased materially.

Oil Cleaners or Filters. Fig. 24 shows an oil cleaner mounted on the side of a Pierce-Arrow engine. These cleaners may be mounted at any position about the engine or engine compartment. As a rule they are so arranged that a portion of the oil which is picked up by the pump is sent through the

cleaner. In the course of time all of the oil will thus be by-passed through the cleaner.

Fig. 25 illustrates a sectional view of a cleaner. It will be noted that within the cleaner there is a section of cloth. This cloth is sewed into a pad and rolled into form. Oil entering at

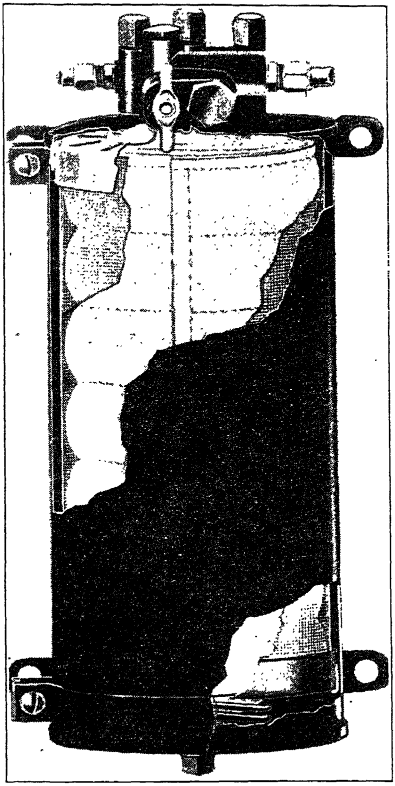


Fig. 25. Sectional View of A.C. Oil Cleaner

one end of the roll, between several layers of the cloth, finds its way around through the cleaning element until finally it is forced out at the other end of the roll. An idea of how this works may be gained by referring to the sectional oil cleaner in Fig. 13 at *C,* where the white line indicates the path of the oil.

In case the oil filter becomes clogged, no oil is by-passed through it and the cleaning operation ceases. For this reason it is a good plan to have the cartridge within the oil cleaner renewed each 10,000 miles of engine service.

CRANK-CASE SERVICE

Draining Crank Case. Engines not equipped with any form of oil cleaner or purifier will require more frequent crank-case service than those which are thus equipped. Engine manufacturers' recommendations vary from draining twice a year or each 2,500 miles to draining each 500 or 1,000 miles. The garage man will have to inquire into the conditions of operation of any car which is being serviced in order to know the best recommendations to make in the case of the individual cars. An inspection of the oil is always easily made and will indicate conditions within the crank case. When oils show black and smell of carbon, the crank case should be drained. In case the car is equipped with an oil rectifier, the cleaner itself should be gone over to make certain that it is working properly. In many cases it will be necessary to renew the cleaning cartridge.

Draining the oil from the crank case removes much of the undesirable condition but seldom all. The reason for this is that there are troughs and pockets in which the oil will remain. Another reason is that after many miles of service there is a certain deposit within the crank case which will not readily drain off.

The best time to drain oil from the crank case is after the car has had sufficient running to warm up the oil thoroughly, at which time it will flow more readily and carry away the greatest quantity of contamination.

Most crank-case service work is done over a pit or on a grease rack. The grease rack should be provided with a funnel and flexible tube which would allow the oil to be drained into a barrel. In crank-case service too much care cannot be used in seeing that the work is done properly. When removing the drain plug, care should be used to see that the corners of the

plug are not rounded and that it is not turned in the wrong direction so as to lock it so tight as to damage the ferrule, which is usually sweated or brazed into the oil pan. The drain plug should always be cleaned and the gasket, if such is used, should be inspected to see that no dirt is present on it. Under no circumstances is it to be left out. There are many cases on record where filling-station attendants did not replace the plug properly or did not replace it at all. The drain plug is not replaced until all oil which will flow from the crank case has been drawn off.

Flushing Crank Case. There has been considerable discussion as to whether or not crank cases should be flushed with cleaning oil. In most instances the practice is frowned on by car manufacturers, although there are a few who still recommend it. Generally speaking, there can be little harm in flushing out crank cases with paraffin oil or a cheaper grade of lubricating oil. It is true that there will be some part of this oil left within the crank case to dilute the new oil put in when the flushing oil has been drawn off.

Where a crank case has been allowed to become very badly contaminated with water, dirt, and gasoline and where considerable quantities of carbon seem to be present, it is a good plan to recommend to the car owner that a cheap grade of new oil should be put into the car and the engine operated long enough to warm up this oil and flush it around thoroughly. This new oil is then drawn off before the car leaves the station and the proper grade and amount of oil is filled into the crank case. While this will cost the owner of the car a bit of money, it will put the car in a much better condition and more than offset the cost for the oil used for flushing. For this work it is not a good practice to use light oil such as paraffin in every case coming to the service station. If the car manufacturer recommends the use of paraffin oil, then the service-station attendant may know that the oiling system is so designed as to permit of its use. It is better to use a light grade of lubricating oil when there is any question as to whether the system will permit the use of paraffin oil. This light grade of oil will

quickly flow through the parts and flush them out, carrying away the deposits of carbon, dirt, etc. Do not operate the car on this flushing oil.

Where full-force-feed oiling systems are used, there seems to be some criticism with reference to the use of paraffin oils or kerosene for flushing crank cases. Where the splash-and-circulating system is used, the troughs in the upper oil level will retain a great deal of the kerosene, if it is used, and this kerosene will immediately dilute the new oil when it is poured into the crank case. For this reason it is condemned for splash-and-circulating jobs.

Generally speaking it is necessary to drain the crank case oftener in the winter than in the summer. This is due to the fact that the drives are more often of short length and the engine is harder to start and crank-case dilution is therefore more rapid. Contrary to the usual conception of car owners, a little kerosene within the crank case is not so dangerous as might seem at first thought. As a matter of record there are certain companies which recommend the use of a pint of kerosene to each gallon of lubricating oil in the crank case of their engines, for extremely cold weather. This is to insure that the oil will flow freely and that the engine will not be damaged before lubrication starts. It must be remembered that where pressure lubrication is used, with the oil being forced through the crank shaft to the connecting-rod bearings and thrown from the ends of the rod bearings into the cylinder walls, that heavy cold oil will not come through until the engine has been in operation a sufficient length of time to warm up the oil and the rod bearings. Under these circumstances no oil is being thrown into the cylinders to lubricate them and the pistons. Scoring may result before the oil warms up sufficiently to permit lubrication; therefore the suggestion that a little kerosene in the oil for extremely cold climates is given. A word of caution is needed in this connection, however. Where engines are to be driven over long periods of time, under hard service, the kerosene should not be used. Rather the engine should be warmed up slowly and the grade of oil recommended supplied.

Filling Crank Cases. Practically all oil refiners furnish charts with their oils, showing the exact grade of oil recommended by the engine manufacturer for any particular car. Too much thought cannot be given to this practice by the filling-station attendant or owner. Under no circumstances should oil be supplied to an engine which is not definitely known to be adapted to that engine. Motorists do not object to paying fair prices for high-grade oil, since they realize that the crank-case lubrication is perhaps the most important attention and service which can be given to their engines.

Another feature which demands extreme care is to see that the right amount of oil is put into the crank case to fill it to the level for which it has been designed. If less than the proper amount of oil is put into the engine, after the old oil has been drained off, the car owner may give the car too much service before he looks at the oil level, with the result that bearings are burned out. On the other hand, if too much oil is put into the crank case, it may rise to a point where the connecting rods will dip into it, and excessive lubrication will result as well as fouling of spark plugs.

Care of Oil Screens. Practically all engines are fitted with screens for removing the heavier particles of grit and abrasive substances which are almost certain to get into the crank case. After considerable periods of service those screens are likely to become clogged. Instances are on record where engine bearings failed because of the fact that the screens were clogged and no oil could be drawn through them. In case considerable moisture gathers on the screen, it may become frozen so that the screens are completely blocked against oil. For these reasons it is a good plan to remove the screens from the crank case periodically and thoroughly clean them. In a few cases this is possible when the crank case is being drained. In most instances, however, it is a job which must be sold to the customer if the work is being done at the filling station. If done in the service station, it may be done as part of the repair job.

Caution. When an engine has been drained for repair work, it is a very good plan to immediately flush out all of the

oil lines with clean oil and then blow them out with air pressure. This is a precaution which will prevent much grief later on. When the old oil is allowed to dry in the oil lines, it frequently results in flakes of carbon-like formation which later loosen up and flow through the oil line when the engine is put back into use. These flakes of carbon may find their way into the small openings of the lubricating system and clog them completely. When this happens, of course, the bearings are certain to be burned out.

Replacing Damaged Oil Screens. Fig. 26 illustrates an oil screen which has been damaged by accumulation of sludge in the crank case. Doubtless there was some acid in the sludge

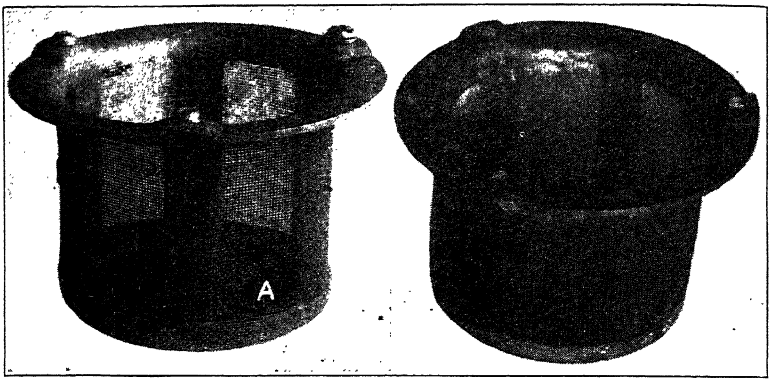


Fig. 26. Left—Oil Screen Damaged by Corrosion
Right—A New Screen Has Been Applied

which ate away the oil screen so as to leave the hole shown at *A*. All that it is necessary to do in an instance such as this is to strip off the old screen and make a repair by soldering on new screen of proper mesh.

Worn Oil-Pump Gears. One cause of loss in oil pressure is worn pump gears, Fig. 27. This condition permits the oil to pass back through the gear teeth and out of the pump through the holes in which the gear shafts are located and consequently the pressure does not build up because little oil is being circulated through the system.

Dropping Crank Case and Cleaning. A good job to sell the customer is cleaning the crank case. This means that the car

may be put up on a rack or over a pit and the crank case dropped down and thoroughly cleaned. It is practically impossible to clean out all of the accumulation of filth and dirt from the crank case unless it is taken down and flushed out with hot water or by similar means, such as air and water, or by means of a brush and kerosene. Any car owner is easily sold on the proposition that this accumulation of dirt being picked up by the oil and forced through the lubricating system is certain to be very costly. He knows it is impossible to draw off all of this accumulation of dirt. The cost of dropping the

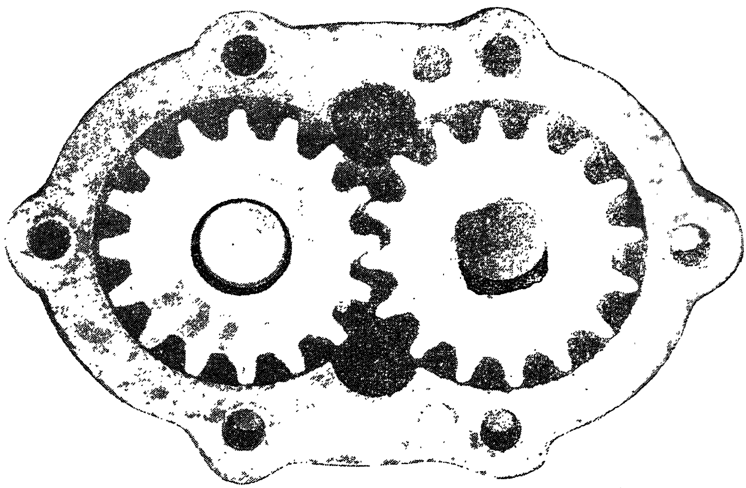


Fig. 27. Photograph of Badly Worn Set of Gears in a Gear Pump
Such gears must be replaced with new ones.

pan and cleaning it is very slight considering the service done the customer in actual saving of money through the prevention of rapid depreciation.

ENGINE CLEANING

When in constant service over the dusty streets and gravel roads such as exist in many communities, the exterior of the engine will become caked and coated with dust which is deposited upon the oil which is almost certain to gather on the outer surface of the engine block and fittings. The average engine emits a certain amount of oil mist from the breather

tubes. This mixes with the dust and forms a coating which, to say the least, depreciates the appearance of the engine.

Some carburetors are so designed that considerable dust may gather about the auxiliary air valve. The splash from the road is always accumulating upon the lower parts of the engine and sometimes gets above the sod pan and fouls the engine. All of these items together contribute to give the engine a very unsatisfactory appearance. Car owners take pride in the appearance of the power plant of the car and it is a comparatively easy matter to sell them on the cleaning job.

When cleaning engines, one of the best methods is to make use of the oil spray in connection with the air line. Cleaners for this work may be secured from the automotive jobbers. The amount of time used is relatively small compared to hand cleaning. Some repair men and service-station men make use of the car washing equipment for cleaning the engine. In this case, the hot water and air combination is perhaps the most satisfactory. A very good line of business can be developed on engine cleaning. Naturally the owner takes some pride in his car and, as a matter of fact, when repairs are necessary they may be made much more easily. It is also a matter of record that the power plant which is kept clean is a safer power plant, as far as the fire hazard is concerned. If there is no accumulation of oil to be burned, fire is far less likely to be started from a backfire or a short circuit. Another item worth considering here is the fact that the controls such as spark and gas, foot levers, brake pedals, wiring, etc., are put in better condition for continuous trouble-free service. Cleanliness pays.

1935 Ford "V-8" Engine. Changes in the 1935 Ford "V-8" engine consist in the addition of a "directed flow" system of crank-case ventilation and the use of high lead bronze for the floating connecting rod bearings, as was the practice in 1934 Ford truck engines. A new cam shaft of cast-alloy iron, the metal similar to that used for the push rods (valve tappets), is used. The cam-shaft bearings instead of operating against the iron of the cylinder block casting are of the pressed-in steel-backed babbitt-lined type.

The crank-case ventilating system, Fig. 28, is designed to remove water-vapor from the crank case, thus preventing possible blocking of the lubricating system from water freezing in the oil in cold climates. Dilution is also reduced. Air enters the engine through a scoop replacing the oil filler cap. It is

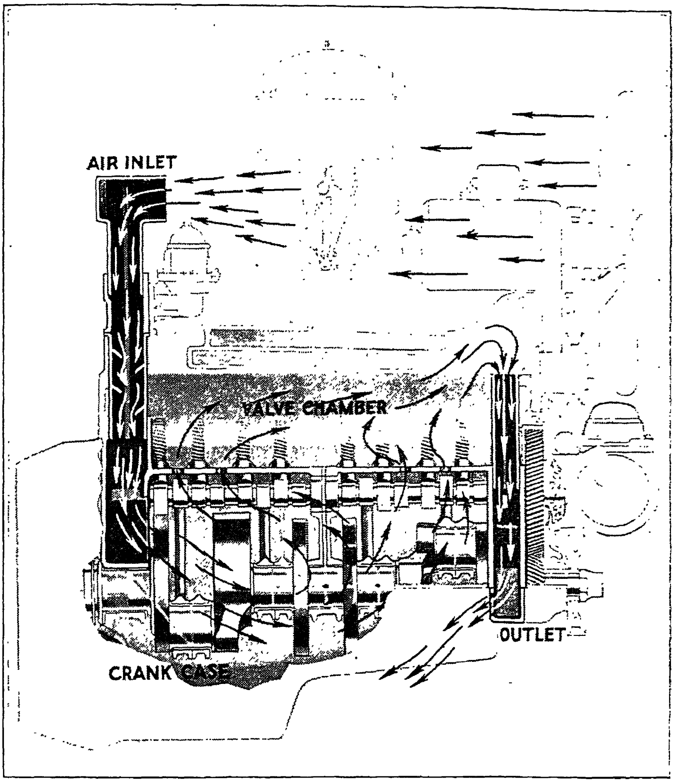


Fig. 28. 1935 Ford "V-8" Engine and Crank-Case Ventilator

then conducted downward into the crank case, whence it flows upward through openings into the valve chamber. Finally it passes downward out of the engine through a special cored passage in the cylinder block casting.

Chevrolet Oiling System. The engine lubricating systems of the 1935 Chevrolet cars in both the standard and master

lines are similar, Figs. 29 and 30. The oil pan, Fig. 29 shows both upper and lower levels, the pan being illustrated as

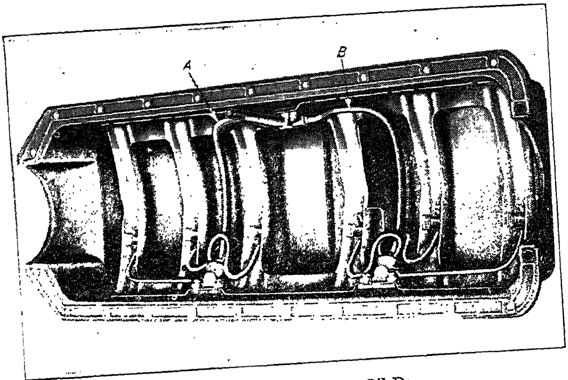


Fig. 29. 1935 Chevrolet Oil Pan

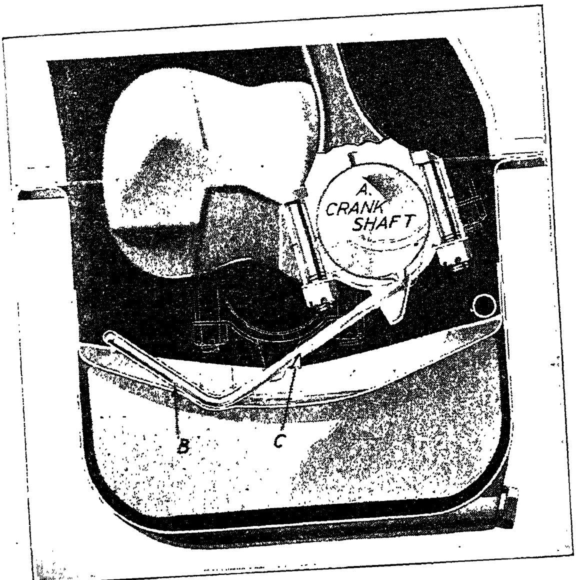


Fig. 30. Chevrolet Oil Jet in Operation

looking down upon it. Oil lines coming from the oil pump have two branches, *A* and *B*. Each of these lines runs to another junction block, at which point three other lines are taken

off, making a total of six, one for each of the upper level oil dipper troughs.

The purpose of these oil lines is illustrated in Fig. 30, where one of the connecting rods, dipper troughs, and oil lines

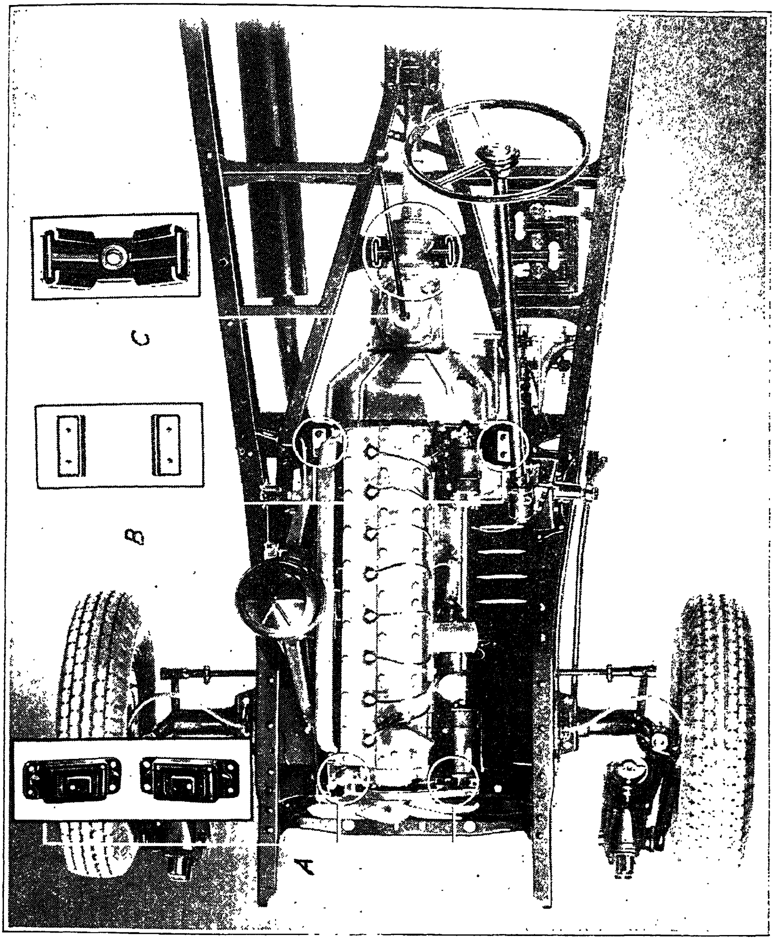


Fig. 31. 1935 Pontiac Power Plant Mountings Which Absorb Torque Reaction and Vibration

are shown in detail. The rod journal is shown in cross section at *A* and beneath it is the large dipper. A stream of oil, *C*, is being sprayed into this dipper as the connecting rod turns.

Since the size of the oil pump has been increased and the quantity of oil delivered is greater, since the force of the oil stream coming from the oil nozzle *B* is considerable, and further since the direction of rotation of the connecting rod is toward the oil stream, it will be seen that oil starts to enter the bearings at an earlier point in the rotation of the rod and a considerably greater pressure is available to force the oil into the connecting rod as the rod moves downward and over

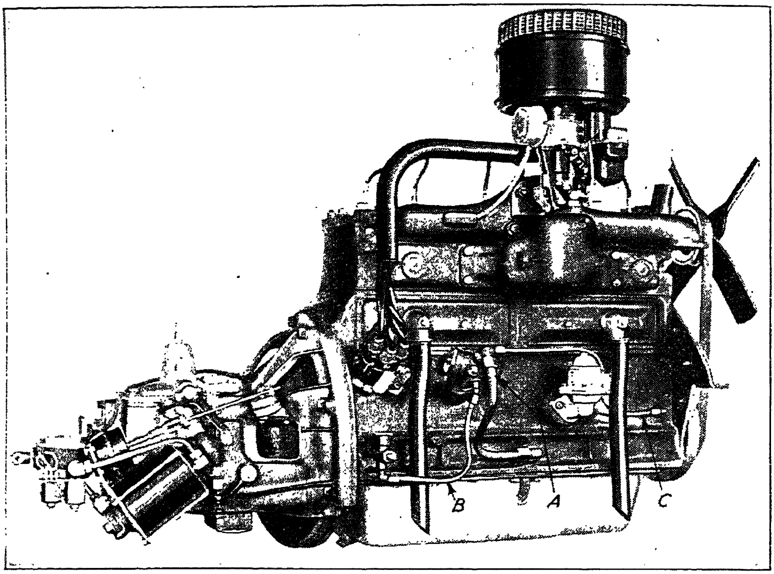


Fig. 32. Right Side of Terraplane Six Engine Which Develops 88 Horsepower with a 6-1 Compression Ratio Secured with a 7-1 Compression Head

towards the oil nozzle. The connecting rods are provided with larger oil grooves than formerly and at the bottom where the oil grooves cross there is a large pocket, thus providing a reservoir which is filled each time the dipper passes through the oil jet.

Pontiac Engine Mounting. The five rubber engine mountings used on the 1935 Pontiac automobile are illustrated in Fig. 31. The engine is shown moved forward over the front axle, approximately five inches. The tendency of an engine

to roll on its engine mounts when power is applied, is well known to all auto mechanics. This is due to what the engineers call "torque reaction," its effects being shown by the tendency of the engine to move sidewise or for the frame of the car to move under the engine. When incorporating rubber in the engine mounts, it is possible to absorb this torque reaction without having it affect the comfort of the passengers in the car. The line *A* indicates the two forward engine mounts, the one at *B*, the rear engine mounts, and the one at *C* illustrates

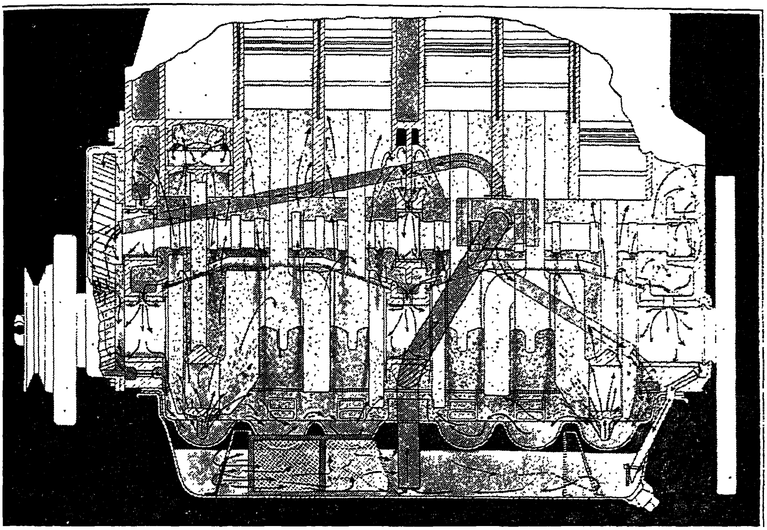


Fig. 33. Diagram of Flow of Oil in Duo-Flo Oiling System Used in Terraplane and Hudson Cars

the rubber mount used under the transmission at its rear. The power plant is thus supported at five points.

Splash Lubrication of Hudson and Terraplane Engines. The position of mounting the oil pump on the Terraplane Six, the Hudson Six, and the Hudson Eight 1935 engines varies somewhat but the general principle of lubrication remains the same. This is splash lubrication. The oil pump, which is shown at *A*, Fig. 32, is mounted on the outside of the engine and operated from the cam shaft and serves to draw oil from the oil sump through a large tube, shown on the outside of the

engine, and to send it to each end of the engine, as shown, through the smaller oil lines B and C.

In a sectioned view of the engine, Fig. 33, the duo-flow characteristics of the oiling system are illustrated. The large

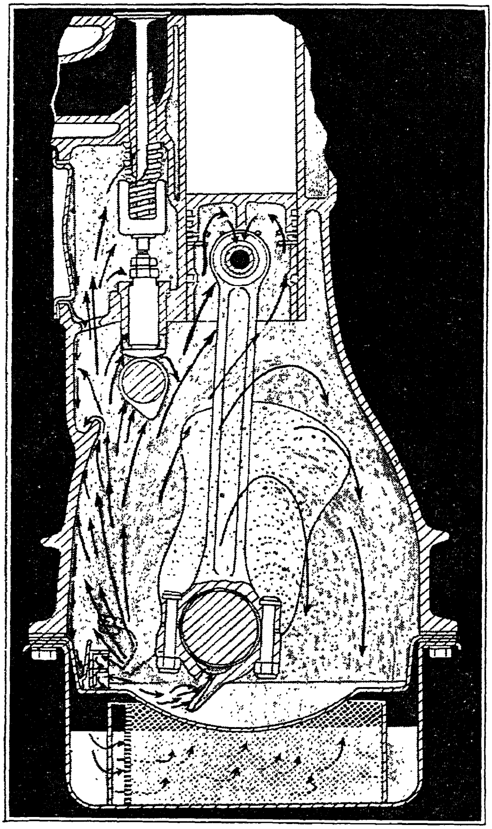


Fig. 34. Cross Section Showing How Oil is Circulated to Cam Shaft and Pistons in Hudson Duo-Flo System

tube which runs to the sump has arrows within it pointing the way to the pump. From the pump one line runs to the rear of the engine at which point oil is sprayed onto the rear main bearing, from which position the surplus finds its way back toward the center of the oil pan and is picked up again

by the oil suction line. The other line runs to the timing gears and forces a stream of oil on them, from which position surplus oil drains back past the main bearing to the upper oil level of the crank case, filling the troughs as it flows toward the rear of the engine to be picked up again and recirculated by the suction tube.

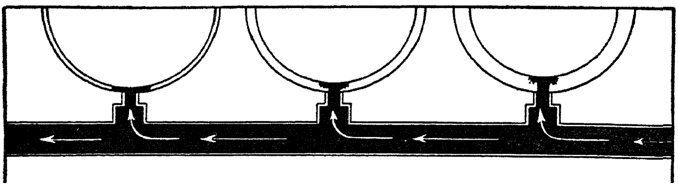
All oil is screened over and over as it is forced through the system. Fig. 34 illustrates in cross section view just how the oil is splashed into and onto the working parts of the engine. The large dipper on the end of the connecting rod is drilled so that oil is forced directly into the groove in the lower half of the connecting rod cap. Much oil is splashed out of the oiling trough and follows the paths indicated by the arrows lubricating other portions of the engine, for instance, the cam shaft and bearings, the cams and valve lifters, the valves, the piston pins, the cylinder walls, the rings, mains, accessory shaft, and in fact all working parts of the engine.

In Fig. 34 the bottom face of the valve lifter or tappet is provided with a curved surface, this surface being on approximately a three-inch radius. It has been found that by providing this type of arc to the valve lifter surface considerable increase in horsepower has been secured, owing to the fact that the length of time the valve is held open, that is, the valve dwell, aids in securing a better fuel inductance into the combustion chamber.

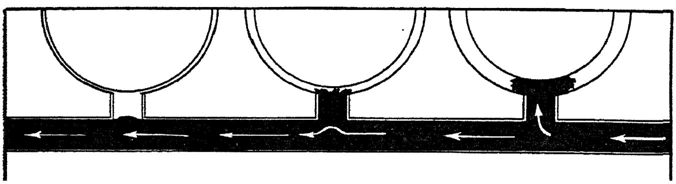
Pontiac Connecting Rod Bearing Lubrication. Lubrication in the Pontiac engine is accomplished by the full-pressure metered-flow system. This means that, irrespective of connecting rod wear or clearance, the quantity of oil fed to the bearings will always be the same, and in correct amount.

Any liquid, under pressure, will take the path of least resistance. Without the metered flow, the bearing with the greatest amount of wear, or clearance, will allow the greatest amount of oil to flow through it. Oil will leak out at the ends of the bearing, thus reducing the pressure of oil to other bearings in the system. This results in overheating bearings, and rapid wear of bearings starved for oil. With metered flow, all bearings receive the same amount of oil, as shown in Fig. 35.

Graham Cylinder Lubrication. To secure instantaneous cylinder lubrication in cold weather, Graham engineers have provided a special lubrication system designed to place oil into a groove which runs around the lower portion of the piston skirt as shown in Fig. 36. Here it will be noted that oil coming through a cored oil passage in the cylinder casting is forced into a channel machined around the valve lifter. When the valve lifter is on the top of the cam, it will be noted that a drill



METERED FLOW. EQUAL AMOUNT OF OIL TO ALL BEARINGS



CONVENTIONAL. WORN BEARING RECEIVES MOST OIL

Fig. 35. Pontiac Metered-Flow Engine Lubrication
Courtesy of Pontiac Motor Company, Pontiac, Michigan

hole from the larger passage permits oil to come into the groove around the lifter and also to pass out into a drill passage just above. From this point it passes around the piston when the groove in the piston skirt registers with the small cross hole in the cylinder wall. Arrows indicate the path of the oil flow.

Engineers claim that much of the wear on engines is occasioned by failure of the oil system to start proper lubrication at the instant the engine is started. This is especially true in cold weather when the oil is slow to flow. Scuffing and scoring of the cylinder walls and pistons are likely to occur at that time. The Graham instantaneous cylinder lubrication system is designed to offset this condition.

Crank-Case Oils and Temperatures. The thermometer

chart, Fig. 37, shows in a graphic manner just how oils should be selected for the Chevrolet motor. As the temperature of the weather falls, the viscosity of the oil used should be decreased. Starting at the top of the chart, it will be seen that S.A.E. No. 30 oil is recommended for temperatures from 50 degrees to 110 degrees. This would be normal summer time use. Dropping down to the next bracket which shows S.A.E. No. 20, it will be seen that this oil is permissible from approximately freezing to

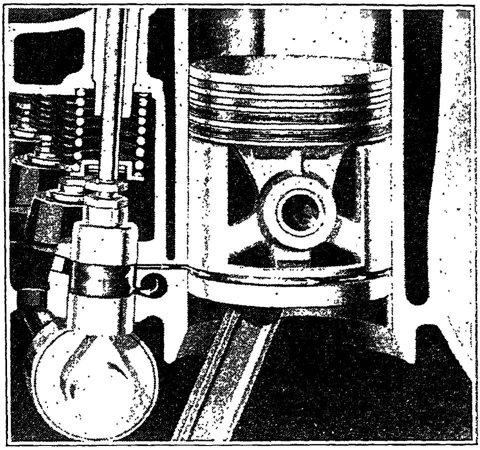


Fig. 36. Graham Instantaneous Cylinder Lubrication on 1937 Cars
Courtesy of Graham-Paige Motors Corporation

100 degrees. Thus, it will be found that there is a wide overlapping of the No. 20 and No. 30 oils, say for the range of 50 to 100 degrees.

On the opposite side of the thermometer, it will be noted that 20-W. oil is used from 10 above zero to as high as 80 above. Thus, again we find an overlapping of the range of the oils from approximately 30 to 80 degrees. Note that this is another 50-degree lap.

For the average winter in states where the temperature does not often drop below zero, a 10-W. oil is recommended, this being for a temperature of from 10 below to approximately 45 above. Here it will be noted that the overlapping is approximately 35 degrees.

For extremely cold winter weather where the temperatures may drop as low as 30 or more degrees below zero, a 10-W. oil plus 10 per cent kerosene is recommended. The kerosene is added to secure a lubricant which will pour or flow at temperatures below zero. Here for the first time it will be seen that the oil recommended is not to be used when the temperature goes above freezing, in fact, not above 20 degrees above

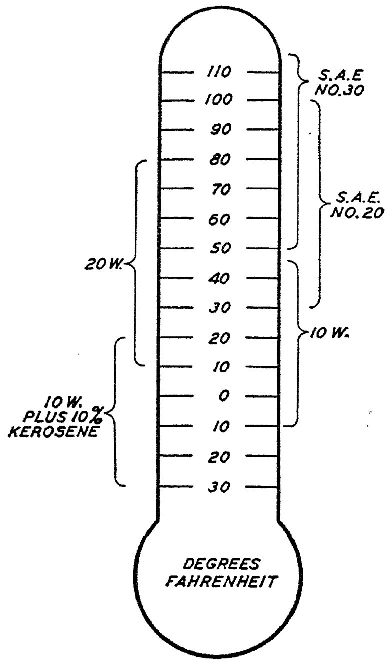


Fig. 37. Chevrolet Engine Lubrication Chart
Courtesy of Chevrolet Motor Company

zero to 30 degrees below, the total range of this oil being just 50 degrees, as shown on the chart.

The chart illustrated will serve as a guide for other cars aside from the specific car for which it was prepared. There has been a marked tendency to lower the S.A.E. numbers recommended for engine operation of modern high-speed automobile engines. Formerly, oils as heavy as 40, 50 and occasionally 60 were recommended for engine crank-case lubrica-

tion, but these heavier oils are not so much in favor with the manufacturers of the modern high-speed motor cars.

The reader should remember, however, that this chart is not given here as being the one to follow in all cases of all motor cars. It is simply a reference which gives the trend of the times in engine lubrication. It is understood, of course, that in all cases where service men are charged with lubricating auto-

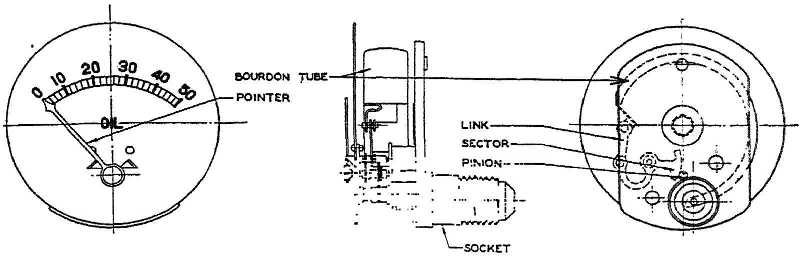


Fig. 38. Geared Type AC Pressure Gauge
Courtesy of AC Spark Plug Company

mobile engines, which carry with them a recommendation and in fact almost a guarantee of service, it is necessary to follow very carefully and exactly the recommendations of the motor car manufacturer. Usually these recommendations are available through the oil companies, as well as through the dealer agencies of the car. Every service man should protect his interest by following authorized lubrication recommendations.

Operating Principle of AC Pressure Gauges. The common pressure gauge used for registering the amount of pressure developed within the oiling system of the automobile or in the compressed air lines or similar uses is usually of the Bourdon tube type. A cross section of the Bourdon tube would be elliptical in shape. A side view of this is shown in Fig. 38 (center) and at the right an edge view. This tube is so designed that, as pressure comes within it, it tends to enlarge the diameter of the ring in which it is formed. It will be seen that one end of the tube or ring is fastened to a post while the other end is swung free and linked to a sector. This sector, in turn, is connected to a pinion gear. That is, the sector has teeth on it and the little pinion gear also has teeth. The indicating hand is

connected to the shaft of the pinion. Thus, as the end of the Bourdon tube, which is free, tends to move away from the fixed end, it has the effect, through the linkage, of moving the sector on the pinion with the result that the hand is moved about on the face of the instrument which is shown at the left.

Inasmuch as these indicators or gauges are calibrated to very fine limits and over specific ranges, the workman who is servicing one of them must be very careful never to exceed the indicated pressure for that particular instrument. To do so will cause the metal of the tube to be forced out of its original elliptical shape and destroy the working of the instrument. The same type of tube may be utilized for pressures as low as a few pounds per inch to as much as 2,000 and even more pounds per inch for certain pressure systems. The point is that the Bourdon tube is designed to withstand the pressures incidental to each service.

CRANKCASES AND ENGINE LUBRICATION

1939 CHEVROLET OIL DISTRIBUTOR BODY

The prime purpose for the redesigning of the oil distributor body was to secure positive lubrication to the rocker arms, push rods, and valve stems, at any and all car speeds. The immediate lubrication of the valve mechanism is secured by means of a by-pass leading from the high pressure side of the oil distributor into a cavity from which a pipe fitting and pipe permit oil to be carried up to the valve mechanism. In order to prevent over-lubrication, the device, Fig. 1, is provided with a metering hole in the pipe fitting, of such size that it prevents over-lubrication of the valve mechanism at high speeds. Sufficient oil is by-passed through the metering hole

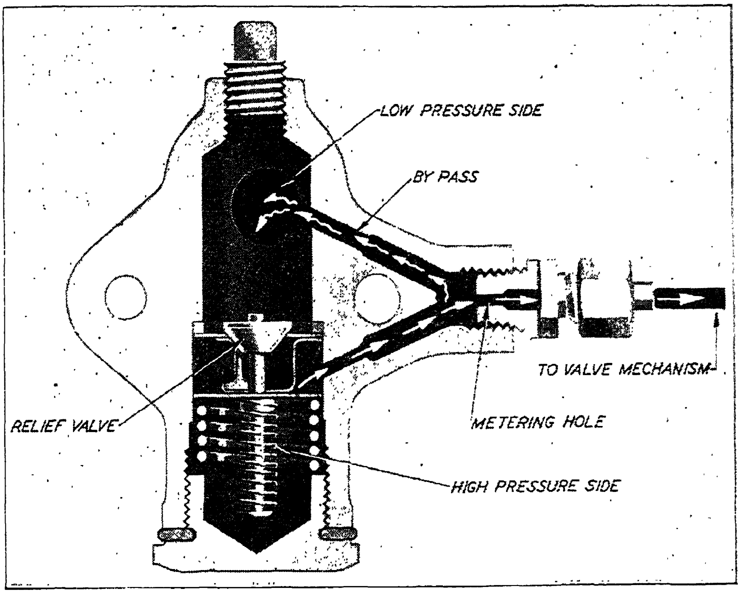


Fig. 1. 1939 Chevrolet Oil Distributor
Courtesy of Chevrolet Motor Division, G.M.S.C.

to allow the valve mechanism to be properly lubricated at low speeds. The over-supply of oil is by-passed through the pipe cavity to the low pressure side of the oil distributor.

BUICK DYNA-FLASH ENGINE LUBRICATION

The system, as illustrated in Fig. 2, is of the force-feed type. The cylinder walls and pistons are lubricated by oil forced through a small hole drilled through the lower end of each connecting rod, which

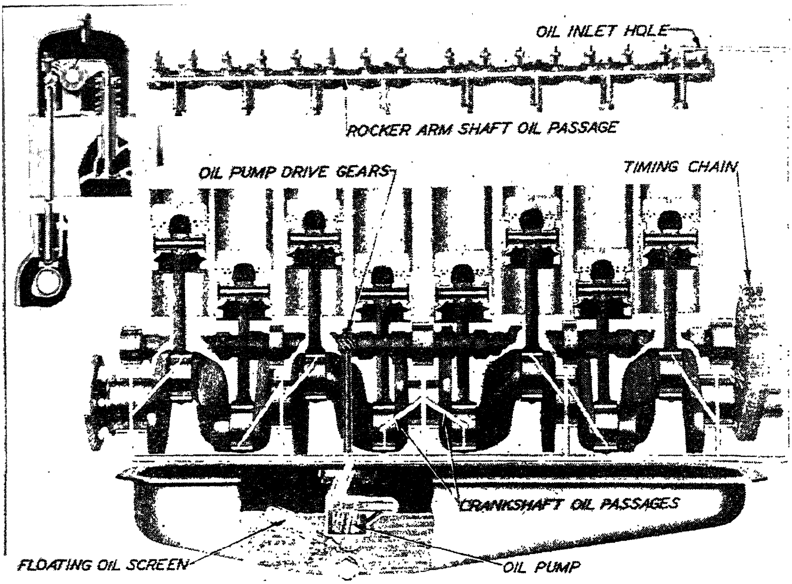


Fig. 2. Buick Dyna-Flash Engine Lubrication System
Courtesy of Buick Motor Division, G.M.S.C.

meters with a hole in the crankshaft once each revolution. Piston pins are lubricated by oil holes in the upper portion of the pin boss. The timing chain and sprockets receive oil through a small passage from the main oil line, which meters with a recess in the backside of the camshaft thrust plate. Rocker arms are lubricated by oil received through a pipe from the crankcase oil passage. The oil inlet hole at the front end of the rocker shaft is $\frac{1}{16}$ inch, which limits the amount of oil which will flow to the shaft—consequently, the pressure on the oil. A small cylindrical screen with one open end

is used under the connection where the oil line to rocker arm assembly is attached to the cylinder head. It is necessary to disconnect this line and remove fitting to gain access to the screen, which may be removed with a hook or small piece of wire. The oil pump, as shown in Fig. 2, is located in the lowest point of the crankcase and is driven from the camshaft by spiral gears. The pump is provided with an unadjustable relief valve. Under normal operating conditions the oil pressure is 45 pounds.

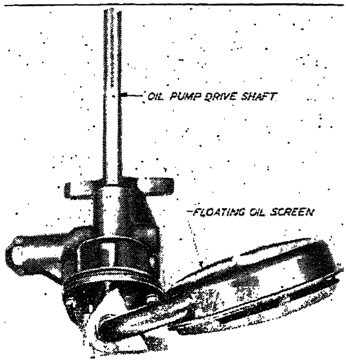


Fig. 3. Buick Floating Oil Screen
Courtesy of Buick Motor Division, G.M.S.C.

Floating Oil Screen. In order to have only fresh oil picked up by the pump, a floating screen, illustrated in Fig. 3, is used. The screen is attached to the lower face of the sheet metal dome with a sealed air compartment. The inlet pipe leading to the oil pump acts as a bearing, about which this dome is free to pivot so that it will float at the top of the oil, but not so high as to pick up any foam which might be on the oil. The floating screen thus prevents picking up sediment which naturally settles to the bottom of the sump. A safety device is incorporated which allows the oil screen to collapse in case it becomes clogged with abnormally thick oil or sludge. In this case the collapsing of the screen at its center opens a valve which allows oil to be drawn to the pump inlet.

Engine Ventilating System. The rotation of the crankshaft within the crankcase, as shown in Fig. 4, is utilized as a blower to force fuel and water vapors from the crankcase through a ventilator outlet pipe welded to the valve lifter compartment cover.

The air pressure built up at the dash enters an opening at the rear of the rocker arm cover and circulates through the rocker arm compartment, carrying vapors with it. The system is not designed to remove all of the crankcase dilution, since a small amount is desirable in cold weather. It does limit the accumulation to approximately 20 per cent, and will remove all water vapor under average driving conditions.

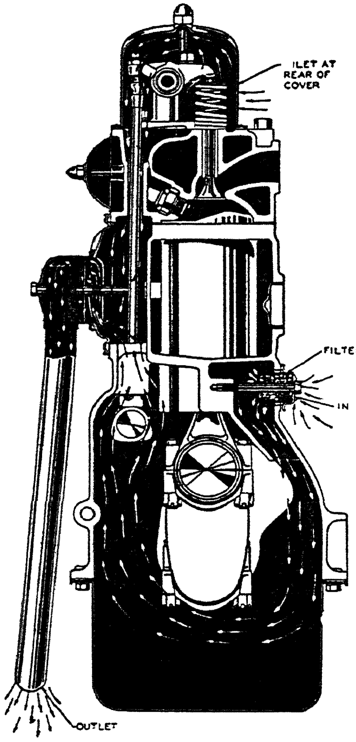


Fig. 4. Buick Dyna-Flash Engine Ventilating System
Courtesy of Buick Motor Division, G.M.S.C.

1941 PONTIAC OIL CLEANER

This new development by the Pontiac Company is a cleaner which is installed as standard equipment in the crankcase of the engine. All of the oil used passes through the cleaner before reaching the oil pump or other working parts. There is no filter element to clog or be replaced. It has been found to be effective under all speeds and temperature conditions. The position of the oil cleaner is shown in the crankcase in the part sectioned view of the engine, Fig. 5. It consists of a settling chamber which is concentric with the oil inlet tube. When the oil, Fig. 6, reaches the top of the inlet tube, its direction is changed so that it flows down the outside of the inlet tube until it strikes a flat baffle and its direction then is sharply reversed. At this point, dirt particles which are heavier than the oil are thrown out of the oil stream into the settling chamber, where they eventually settle or precipitate until they rest on the bottom of the basin. Since the oil below the flat baffle is not disturbed by the flow of oil above the

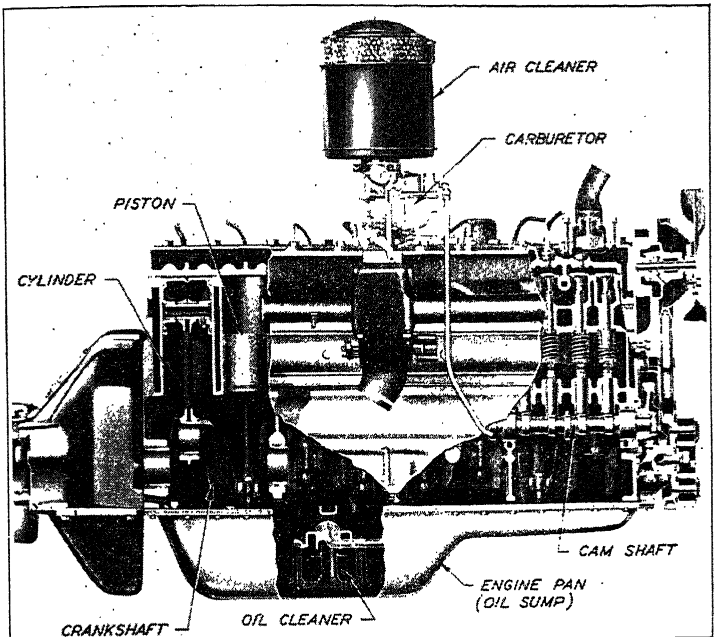


Fig. 5. Sectioned View of Pontiac 8-Cylinder Engine; Oil Filter Built Into Oil Pan
Courtesy of Pontiac Motors Division, G. M. S. C.

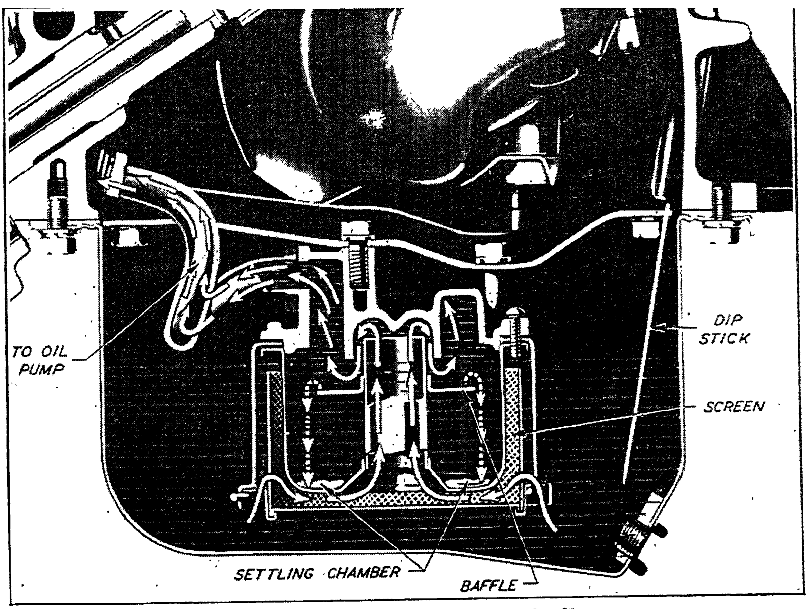


Fig. 6. Principle of Operation of Pontiac Oil Cleaner
Courtesy of Pontiac Motors Division, G. M. S. C.

baffle, the dirt does not re-enter the oil stream. After reversing its direction of flow, as it strikes the baffle, as shown in Fig. 6, the clean oil is sucked into the oil pump inlet tube connected to the die cast cleaner cover through the pump and passes through the pump and on into the engine bearing. Owing to the size of the settling chamber, it is not necessary to remove the pan in order to reach the oil cleaner to clean it.

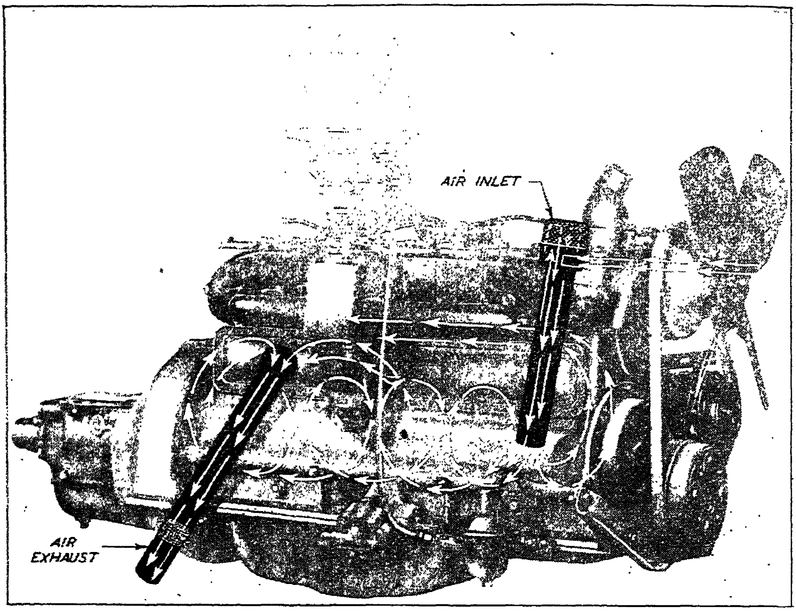


Fig. 7. Phantom View of Pontiac Engine with Crankcase Ventilator
Courtesy of Pontiac Motors Division, G. M. S. C.

In addition to the features of cleaning mentioned above, a fine mesh screen is built into the cleaner to operate as a further protection under low temperature starting conditions. This screen extends nearly to the top of the crankcase oil level, permitting an ample supply of oil to reach the inlet tube in case the bottom of the screen should become closed with ice, as might be the case in extreme cold conditions. The 1941 cleaner can be installed in other Pontiac models and it is especially recommended for use after overhaul or in the dust bowl areas of the country.

PONTIAC 1941 CRANKCASE VENTILATING SYSTEM

The principle of operation of the crankcase ventilator for the 1941 Pontiac is illustrated in Fig. 7. Clean air screened through copper gauze in the oil filter and the ventilating cap is driven into the crankcase by the fan draft, where it circulates through the block assembly and is discharged at the ventilator outlet pipe, carrying with it the

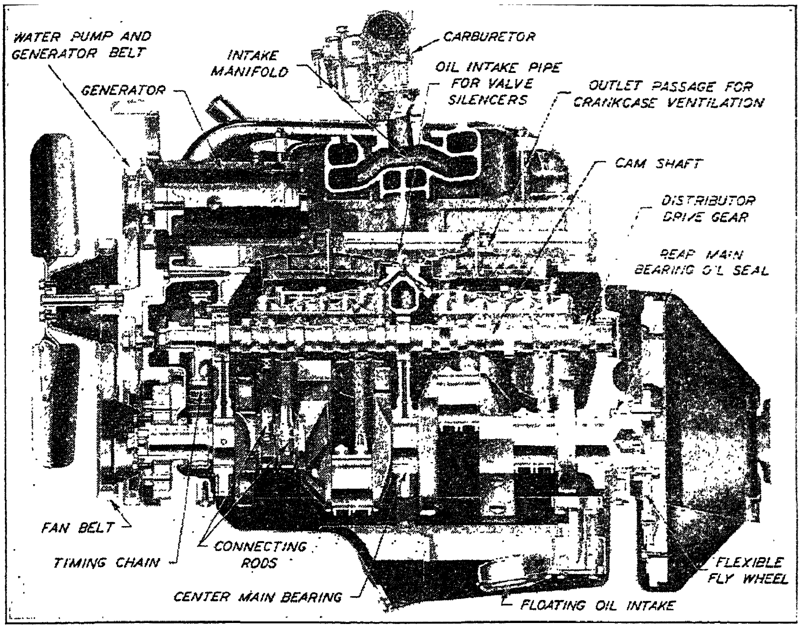


Fig. 8. Longitudinal Cross Sectioned View of 1941 Cadillac Engine
Courtesy of Cadillac Motors Division, G. M. S. C.

water vapor which tends to collect in the crankcase, particularly in cold weather. The operation of the ventilator is automatic. The only care necessary is to see that the cap is properly replaced with the guide in the cap registering in the locating groove in the tube, so that the cap opening is toward the fan, as shown in the illustration.

CADILLAC ENGINE=OILING SYSTEM

The 1941 Cadillac engine is shown in longitudinal cross sectioned view in Fig. 8. The numbering of the cylinders is No. 1, left front; No. 2, right front; No. 3 is No. 2 on left, and No. 4 is No. 2 on right. Thus we have cylinders 1, 3, 5, and 7 on the left and cylinders 2, 4,

6, and 8 on the right. The firing order is 1, 8, 7, 3, 6, 5, 4, 2.

Fig. 9 illustrates the engine oiling system. It will be noted that a gear type oil pump, which is bolted to the bottom of the crankcase at the left of the rear main bearing, supplies the pressure to the engine through drilled passages. A drilled header runs lengthwise of the engine in the left side of the crankcase. From this header there are other drilled passages which branch through the main bearing sup-

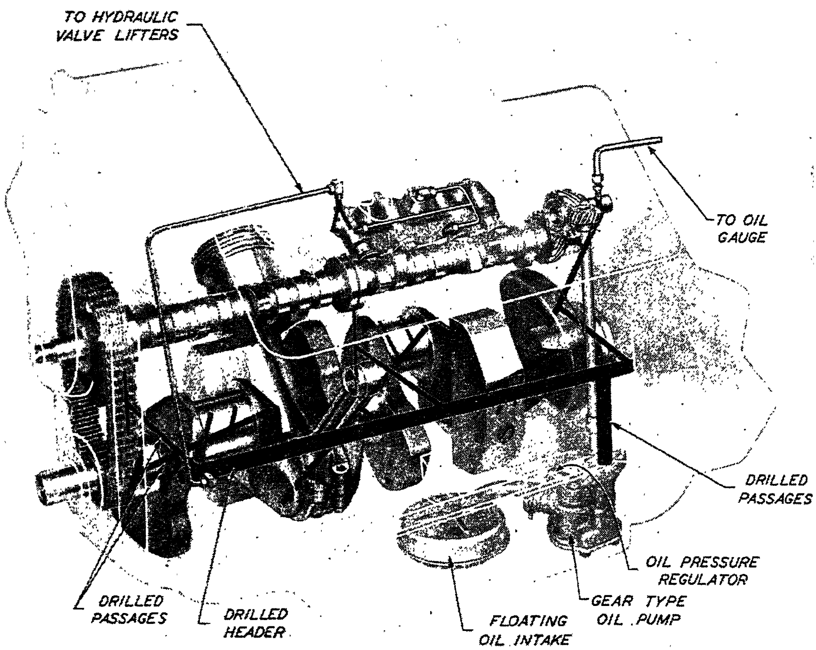


Fig. 9. 1941 Cadillac Engine Oiling System
Courtesy of Cadillac Motors Division, G. M. S. C.

port web to the main and crankshaft bearings. From the main bearings, oil is passed through drilled passages to the crank pins, from which point part of the oil flows up to the piston pins and part is sprayed out to lubricate the cylinder bores. The distributor and oil pump drive shaft and gears are lubricated by oil carried from the rear camshaft bearing. The timing chain is lubricated from the front bearing. The supply for the hydraulic valve lifters is piped from the header. The gage line runs from the system to the instrument panel.

FUEL SYSTEMS

History of Fuel Systems. In the early days the method of handling the fuel was by means of gravity. It seemed that the logical place for the gasoline tank was underneath the seat of the self-propelled vehicle. Accordingly it was necessary to use a very long intake manifold on the carburetor and bring it down near the road, with the result that the engine pans were dropped down considerably in order to secure the gravity feed from the low position of the tank to the carburetor, especially on grades.

This method of handling the fuel had many drawbacks. An early attempt to get away from it was the introduction of an air pump, which was hand operated and which forced pressure into the gasoline tank and thus forced the gasoline through the supply line to the carburetor, which might be higher than the tank. This, of course, facilitated the carburetion in as much as it shortened the intake manifold and raised the carburetor up where it was in a better position as far as cleanliness and repairs were concerned.

These two methods of handling gasoline were in use for quite a few years and eventually the gasoline tank was moved to the rear of the car and the air pump was made automatic in connection with the hand-operated pump so that, once pressure was placed on the tank, the air pump in connection with the engine automatically kept the pressure to a certain predetermined point, controlled by a relief valve. This system was satisfactory and is still used in certain cases.

In order to get away from the use of the air-pressure pump and still have positive feed, the practice of placing the gas tank under the cowl of the car was early resorted to. The Ford Model "A" is the outstanding example of the retention of this method. It has several advantages—it brings the weight toward the front of the car; a short feed line is required; and it has the positive type of feed, Fig. 1.

The invention of the vacuum tank as a means of fuel supply dates back a good many years. In recent years the vacuum system is being displaced by the fuel pump of the diaphragm design. These fuel pumps are operated by means of a cam action from the engine or, in some cases, by means of electrical current. The greatest objection to the vacuum system is the loss of the vacuum when the car is on a long continuous pull and when it is operated at extremely

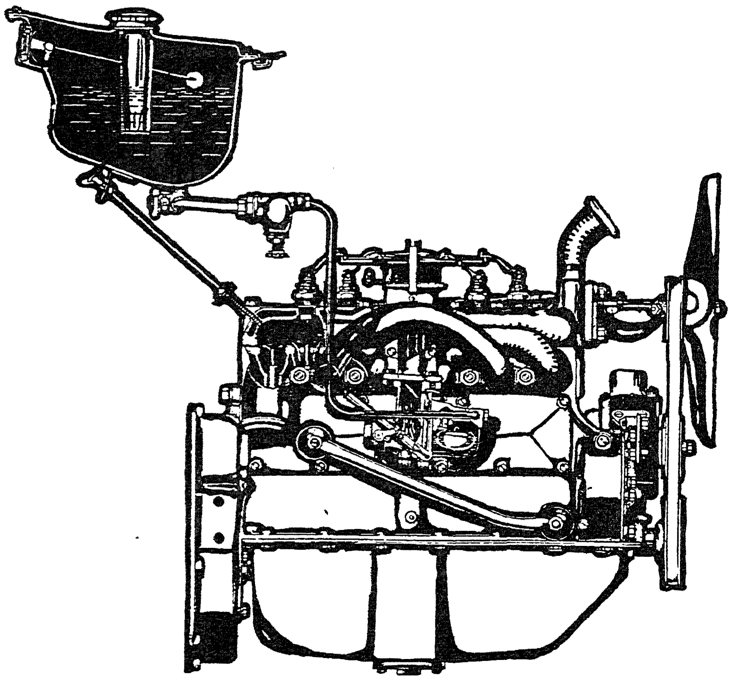


Fig. 1. Ford Model "A" Gravity-feed Gasoline System

high speeds over a long distance. The vacuum developed within the intake lines of the engine is considerable when the throttle is closed. When the throttle is wide open, there is very little resistance to the flowing of air and the vacuum drops off to a few pounds per square inch, with the result that, in case a steep grade is being run with the car, not enough vacuum is secured to force the gasoline from the tank at the rear forward and up to the carburetor. The result is that popping of the carburetor occurs and power is lost. The remedy,

of course, is to close the throttle partially and induce a higher vacuum, but this means loss of power. Under ordinary use the car involves no trouble whatever with the vacuum tank. When used in extremely high altitudes or under conditions mentioned above, which are rare, trouble may develop.

Mechanical Pump Fuel System. Fig. 2 illustrates the layout of the fuel line, pump, carburetor, and air cleaner of a mechanically operated fuel pump system. The mechanical pump serves to draw the fuel from the main supply tank, which is carried at the rear of the car, and then force it on into the carburetor from which point it is drawn by suction into the engine. In the layout of this particular system, attention has been given looking to the defeat of fuel lock

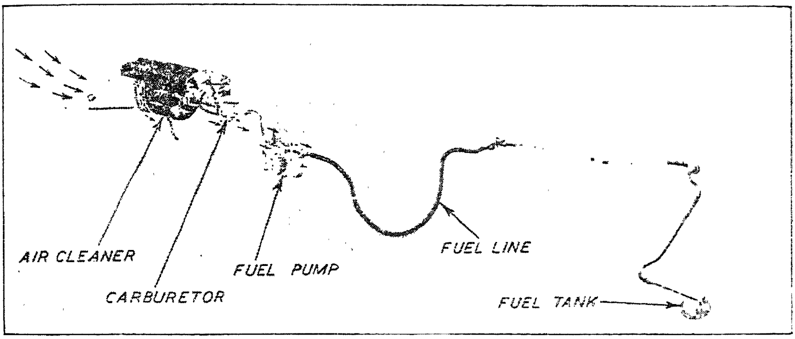


Fig. 2. Buick Fuel System

conditions. It will be noted that fresh air is taken into the horn at the front of the air cleaner from which point it is drawn into and through the air cleaner and thus into the carburetor. Other currents of fresh air pass backward over the carburetor, thereby cooling it and the fuel bowl. The fuel pump being in the line of the flow of air is also cooled. The forward portion of the fuel line which is conducted around the flywheel housing is insulated against heat. The portion of the fuel line which runs forward along the frame member is carried outside of that member in order that it may be cooled. In this manner much of the tendency of fuel to fuel lock, due to bubbles forming in the fuel line, is eliminated. The reader understands, of course, that when bubbles form in the gasoline they prevent the regular flow of the fuel supply to the engine and result in irregular operation of

the engine, as the engine is intermittently starved for a proper amount of fuel.

This particular system is adaptable to use whether the carburetor be of up-draft or down-draft construction. Practically all cars manufactured on a production basis are now fitted with one or another make of mechanical fuel pump. All of these pumps are designed

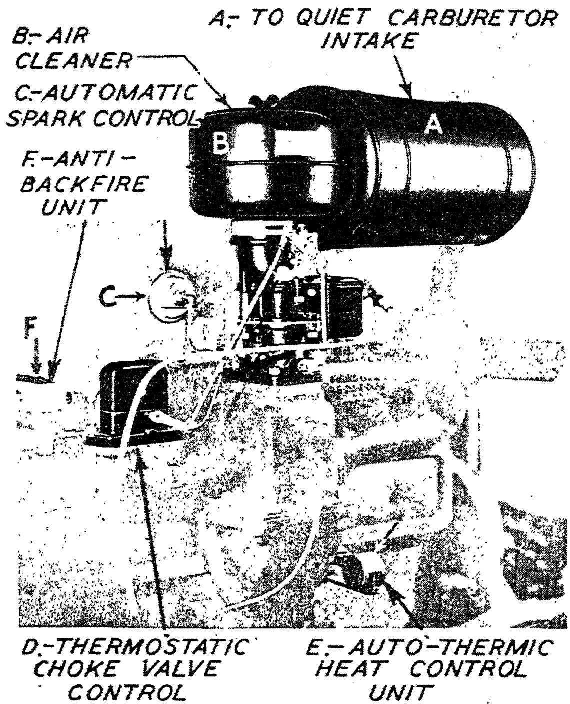


Fig. 3. Studebaker Fuel System

with diaphragms which are operated by means of levers which in turn are operated from cams built onto the camshaft of the engine.

Fuel System Refinement. The fuel supply system of the automobile has been subject to many refinements. Fig. 3 illustrates the Studebaker fuel system with a grouping of some of the refinements offered by that company. For instance in order to quiet the carburetor intake the device illustrated at *A*, Fig. 3, has been incorporated. This is a system of conducting the air through passageways

which are designed to muffle the intake roar. The operation is similar to that of an exhaust system silencing. The down-draft carburetor, of course, is mounted on the upper portion of the intake manifold, which is shown in relief. The upper end of the carburetor serves as a mounting for the air cleaner *B*. This also is a flash-back preventer, so as to eliminate fire hazard. The automatic spark control is illustrated at *C*, this being a scientifically correct spark advance device which is connected to the intake manifold in such manner that the operation of the engine as it affects the suction or vacuum in the carburetor, also acts to advance or retard the spark.

The device *D* is an automatically controlled thermostatic choke valve control which assures constant and perfect ratio of fuel to air and obviates the necessity of the driver manually controlling the choke. This is true even when starting, as the cooling of the thermostatic device within the unit *D* automatically closes the choke and the heat of the exhaust manifold, when the engine starts operating, automatically opens the choke through the action of the thermostatic unit in *D* which is affected by the heat.

A further refinement in the control of the fuel mixture is indicated by the arrow *E*, which shows the auto-thermic heat control unit, which automatically applies heat to the incoming fuel mixture according to the exact needs of the engine. The device *F* is an anti-backfire unit which is designed to automatically protect the mechanism of the engine from damage due to backfire.

Stewart-Warner Leverless-Type Vacuum Tank. The leverless type vacuum tank is constructed with two separate chambers —an inner or vacuum chamber *M* and an outer or reverse chamber *N*, as shown in Fig. 4.

The inner chamber has three openings. The first of these is the fuel inlet *A*, which is connected to the main supply tank. The second is the vacuum opening *P*, which is connected to the intake manifold. The third is the air inlet *H*, which operates through the atmospheric valve.

The pumping action of the pistons in the engine creates the suction or vacuum within the intake manifold of the engine. This vacuum is transmitted to the vacuum tank. Float *F* in the inner or vacuum chamber *M* operates the valve *B* and the atmospheric valve *C*. When the vacuum chamber *M* is empty, the float is down, as is illustrated in Fig. 5. The atmospheric valve *C* is closed

so that no air may enter from the outside. The vacuum valve *B* is open. With this valve open, the suction of the intake manifold is applied to the inner chamber *M* through the vacuum connection, which is a copper tube, and the open valve *B*. This reduces the pressure in the inner chamber *M* below that of the outside atmosphere. This action results in the closing of the flapper valve *G*, as

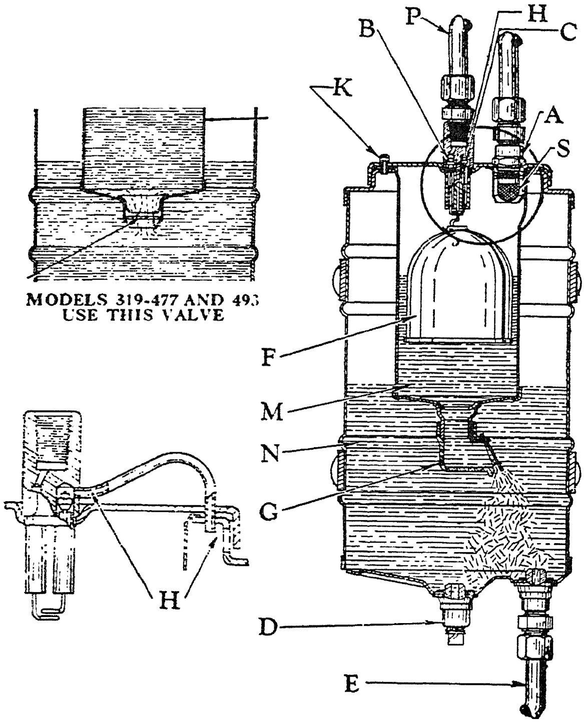


Fig. 4. Stewart-Warner No. 309 Leverless Vacuum Tank

outer chamber *N* is always under atmospheric pressure. Atmospheric pressure of approximately fifteen pounds per inch is always being exerted on the gasoline in the main supply tank. This results in the gasoline in the main supply tank being forced forward through the gasoline feed line and drawn into the chamber *M* through the fuel inlet *A*, which is provided with a dirt screen *S*.

As the gasoline flows into the inner chamber the fuel float F rises. When this float reaches the top of its movement, it automatically closes vacuum valve B and at the same time opens the atmospheric valve C, thus allowing atmospheric pressure to be re-established in chamber M. Since the pressure in both chambers is now equal, the fuel flows by gravity through the flapper valve G

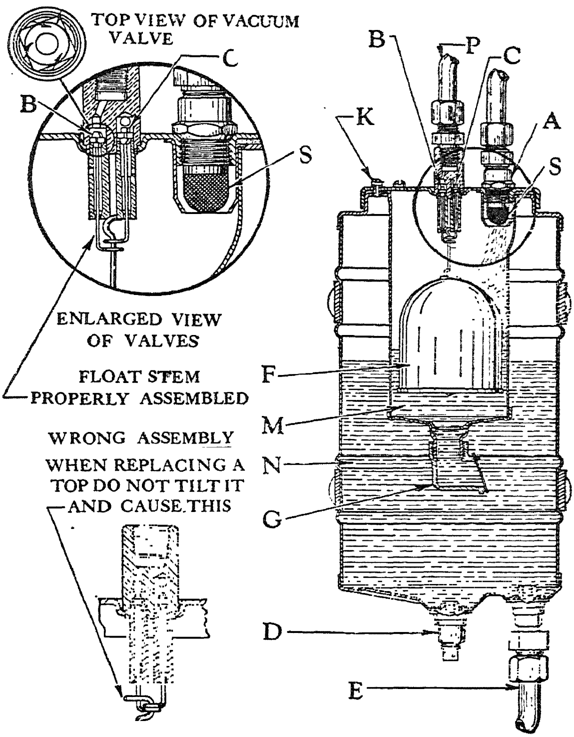


Fig. 5. Illustrating Action of Leverless Vacuum Tank

into the outer or reserve chamber N, allowing the float F to drop gradually.

When the float reaches the bottom of its movement, it opens the vacuum valve B and closes the atmospheric valve C, reversing the action when the chamber is empty. The intake manifold vacuum again lowers the pressure in the inner chamber M and fuel is forced into the inner chamber and the operation is repeated.

This operation of allowing the suction of the manifold to draw the gasoline from the rear supply tank is continuous, being repeated over and over until such time as the fuel level in the chamber *M* comes to balance with the fuel level in the chamber *N*. After that time, the operation of the vacuum tank float is controlled by the amount of gasoline drawn by the engine and the action of drawing gasoline is thereby controlled.

A connection for the windshield cleaner is not provided on the vacuum tank shown in Fig. 5. A bent tube which connects the air valve to the outer chamber is not provided on some tanks. When provided, it is for the purpose of preventing clogging of the air-valve opening.

Servicing Stewart-Warner Vacuum Tanks. First, close the throttle to establish the greatest possible vacuum in the manifold and use the starter to turn over the engine, continuing this operation for about ten seconds. Remove the foot from the starting motor button and allow the job to rest for a few seconds. Ordinarily this will be all that is required to draw a fuel supply from the main supply tank into the vacuum tank and allow it to flow by gravity into the carburetor, after which the engine may be started in the usual manner.

Note. In case dirt becomes lodged under the flapper valve or some other slight irregularity is in evidence, it might be that the cranking operation of the engine would not be sufficient to draw gasoline into the tank. In such cases it would be necessary to open up the tank and pour gasoline into it, opening it either by removing the fuel supply line *A* or removing the filler plug provided in the top of some of the models. This initial charge of gasoline working through the vacuum tank will ordinarily carry away any slight piece of dirt or similar obstruction and thereafter the tank will function properly.

Ordinarily the vacuum tank requires no special care. The tubing fitting should be screwed tight and the half unions screwed on the fitting snugly so as to hold tight at all times and prevent any slight leaks which would interfere with the pumping rate of the device when the engine is operating at high speeds. Foreign matter in the tank will also cut down the pumping rate.

"AC" Fuel Pump. After the advent of the electrically-operated diaphragm pump, new interest was aroused in the positive fuel feed. As a result of this, the engineers shortly produced several models of engine-operated fuel pumps of the diaphragm type. The "AC" pump was well received by the car manufacturers and a great many cars of different models have been equipped with this pump. The main difference in the several models installed is in the method of securing the action of the diaphragm. The principle is practically

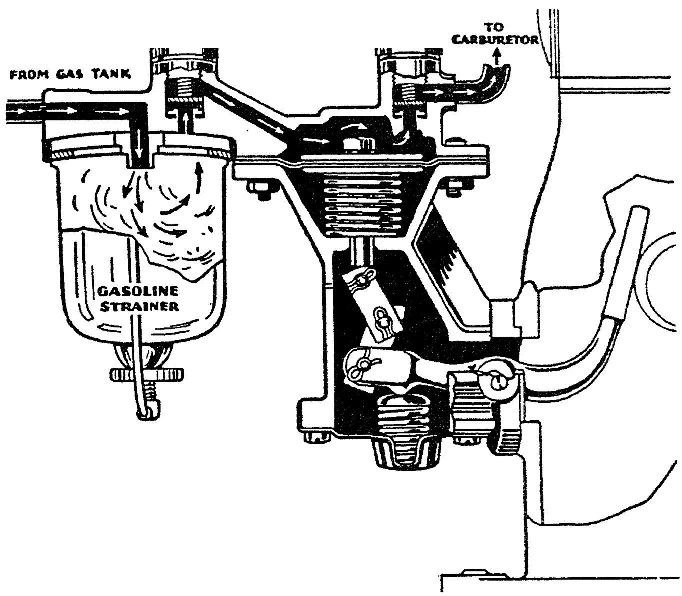


Fig. 6. Sketch Showing Action of "AC" Fuel Pump and Flow of Gasoline

the same in all cases. By referring to Fig. 6, it will be noted that gasoline is drawn in from the supply tank and passes through a gasoline strainer, after which it passes through a valve and over into the diaphragm chamber from which point it is forced through another valve and so on to the carburetor. The linkage, which permits of constant operation of the rocker arm and intermittent operation of the diaphragm, is an important feature.

A complete section of the "AC" pump is shown in Fig. 7 and its complete action is given in the following description. By re-

volving the shaft *G*, the eccentric *H* will lift the rocker arm *D*, which is pivoted at *E* and which pulls the pull rod *F*, together with the diaphragm *A* held between the metal disks *B* downward against the spring pressure *C*, thus creating a vacuum in the pump chamber *M*. Fuel from the rear tank will enter at *J* into the sediment bowl *K* and through the strainer *L* and the suction valve *N* into the pump chamber *M*. On the return stroke, the spring pressure *C* pushes the diaphragm *A* upward, forcing fuel from the chamber *M* through the pressure valve *O* and the opening *P* into the carburetor.

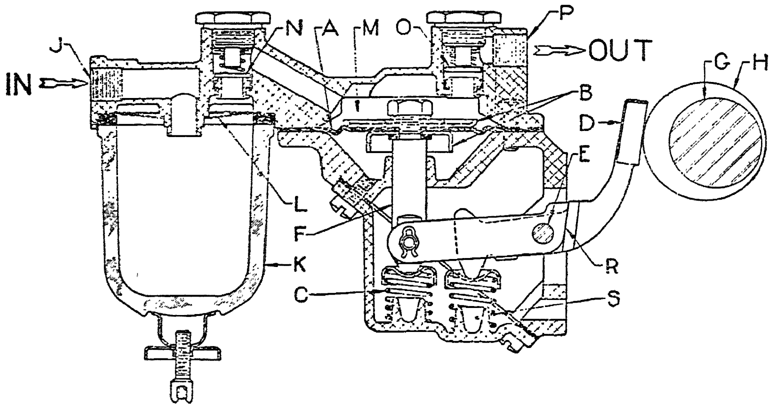


Fig. 7. "AC" Fuel Pump—Sectional View of Type "B"

When the carburetor bowl is filled, the float in the float chamber will shut off the inlet needle valve, thus creating a pressure in the pump chamber *M*. This pressure will hold the diaphragm *A* downward against the spring pressure *C* and it will remain in this position until the carburetor requires further fuel and the needle valve opens. The rocker arm *D* is in two pieces, split at *R* and the movement of the eccentric *H* is absorbed by this "break" *R* when fuel is not required. The spring *S* is merely for the purpose of keeping the rocker arm *D* in constant contact with the eccentric *H* to eliminate noise.

Fig. 8 shows the several methods of mounting the different types of "AC" fuel pumps to the engine. As a rule, the camshaft is provided with a special pump-operating cam although this cam action may be secured from the ignition shaft drive or from the accessory shaft drive.

Servicing "AC" Fuel Pump. Any mechanical device is certain to need repairs at more or less frequent intervals, depending

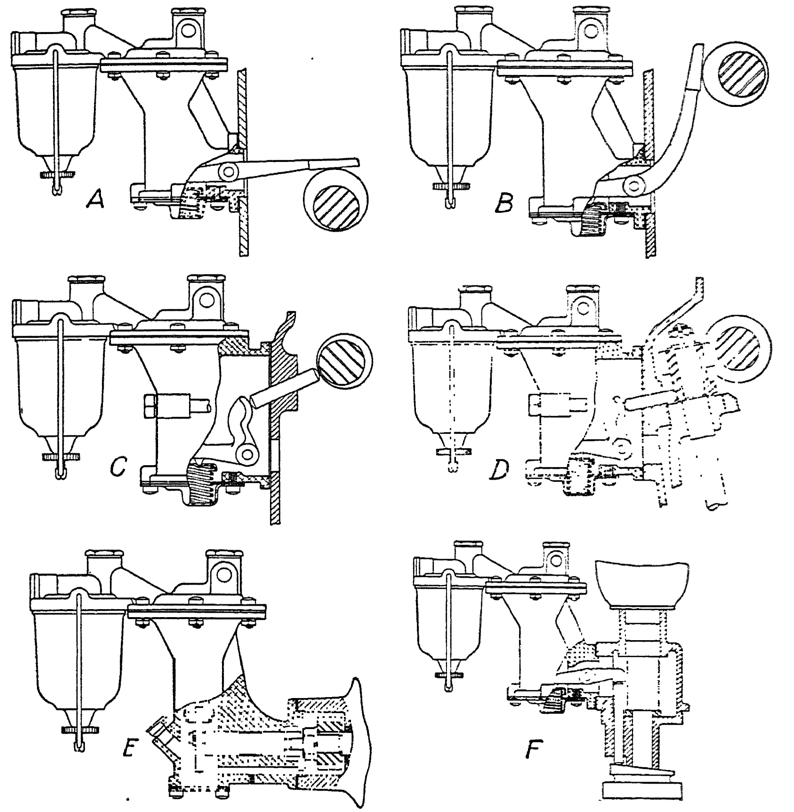


Fig. 8. Several Methods of Installing Several Types of "AC" Fuel Pumps

A—Standard installation operating from engine camshaft with straight pump lever arm.

pump lever arm.

; eccentric and pump lever arm. Lubrication is provided through opening into crank case, using oil vapors.

D—Typical installation operating from vertical shaft and special eccentric on gear hub. using push rod between eccentric and pump-lever arm. Lubrication is provided through opening into crank case, using oil vapors.

E—Typical installation for auxiliary shaft end drive. Recommended for maximum speed 2000 R.P.M. Automatic lubrication must be provided.

F—Typical installation using side cam on lower end of a vertical shaft with push rod between cam and pump-lever arm. Lubrication is provided through opening into crank case using oil vapors.

upon the amount of service given. The following chart will suggest the cause of any trouble which is likely to arise, as well as the remedy, in case such trouble is evident.

LACK OF FUEL AT THE CARBURETOR

Cause	Remedy
Gasoline tank empty	Refill
Leaky tubing or connections	Replace tubing and tighten all pipe connections at the fuel pump and gasoline tank
Bent or kinked tubing	Replace tubing
Glass bowl loose	Tighten thumb nut, making certain that cork gasket lies flat in its seat and not broken
Dirty screen	Remove glass bowl and clean the screen. Make certain that cork gasket is properly seated when reassembling
Loose valve plug	Tighten valve plug securely, replacing valve plug gasket if necessary
Dirty or warped valves	Remove valve plugs and valves. Wash valves in gasoline. If damaged or warped, replace them. Examine valve seat to make certain there are no irregularities which prevent proper seating of valves. Place valve in valve chamber with the polished side downward. Make certain that valve lies flat on its seat and is not left standing on edge. Reassemble valve plug and spring, making certain that spring is around the lower stem of the valve plug properly. Use new gasket under valve plug if necessary.

LEAKAGE OF FUEL AT THE DIAPHRAGM

Cause	Remedy
Loose cover screws	Tighten cover screws alternately and securely. CAUTION: Do not disassemble the pump body. NOTE: Sometimes there appears to be a leak at the diaphragm, whereas the leak actually exists at one of the pipe fittings and the fuel has run down the pump to the diaphragm flange, appearing to originate there.

FLOODING OF CARBURETOR

Cause	Remedy
Carburetor needle valve not seating	Check carburetor for proper adjustment.

IMPORTANT. It is best not to attempt to disassemble the fuel pump further than just described, because it is necessary to use a special fixture in reassembling the pump when once taken apart. When the above remedies do not correct the condition, replace with a new fuel pump, sending the old fuel pump to your nearest "AC" service station.

BUICK FUEL AND VACUUM PUMP

Fuel Pump. The type "I" AC combination fuel and vacuum pump is used on the 34-50 series and is mounted on the right side of the crank case, being driven directly by an eccentric on the crankshaft through a push rod *AA*, Fig. 9, supported in bosses in the crank case. If necessary to remove the push rod, first remove the cover plate. In doing work on this type of equipment, cleanliness and good tools are prime essentials.

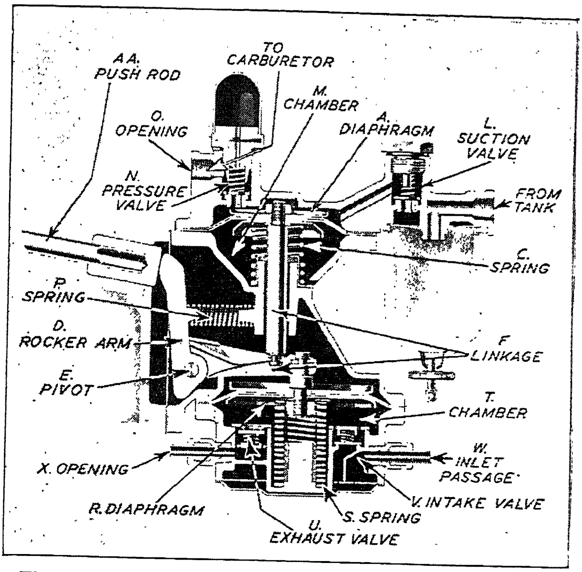


Fig. 9. Combination Fuel and Windshield Wiper Vacuum Pump

The fuel pumping unit on all series is of extra large capacity to insure an adequate supply of fuel at all speeds and under the most extreme temperature conditions. This is a large factor in overcoming difficulties encountered in the use of highly volatile gasolines now being marketed. The vacuum pump unit acts as a booster to augment the intake manifold suction in the operation of the windshield wiper. This arrangement provides powerful and positive wiper operation at all times and overcomes the previous objection to vacuum-type wipers which was the failure to operate on acceleration

or with the throttle wide open. These pumps combine in one unit a fuel pump and a vacuum booster pump.

Gasoline Pump. The operation of the gasoline pump unit is as follows. The rotation of the eccentric on the camshaft actuates the rocker arm *D*, Fig. 9, (through an operating rod on 34-60 and 34-90 series) pivoted at *E* which pulls the linkage *F* and in turn the diaphragm *A* downward. The downward movement of the diaphragm *A* creates a vacuum in the chamber *M* which draws fuel through the suction valve *L* in the outlet of the fuel filter. On the return stroke of the rocker arm *D*, the spring *C* moves the diaphragm *A* upward, forcing fuel from the chamber *M* through the pressure valve *N* and opening *O* to the carburetor. When the carburetor bowl is filled, the carburetor float closes the inlet needle valve which

FUEL PUMP TROUBLE CHART

Trouble	Evidenced By	Remedy
Broken rocker arm	Visible	Replace rocker arm
Broken rocker arm spring	Visible	Replace rocker arm spring
Defective or worn links	Pump noisy and does not supply sufficient fuel	Replace links. Also check for air leaks
Broken diaphragm return spring	Does not supply fuel to carburetor	Replace spring
Punctured or worn-out fuel pump diaphragm	Fuel leaking through vent hole in body	Replace complete diaphragm. Do not attempt to replace just one or two layers
Leakage around pull rod	Fuel leaking through vent hole in body	Replace pull rod gasket, tightening pull rod nut securely
Leakage at diaphragm flange	Visible	Tighten cover screws evenly and securely

creates a pressure in chamber *M*. As the pressure above the diaphragm *A* increases, its stroke lessens to the point where the pressure in chamber *M* overcomes that of the spring *C* and the movement of the diaphragm *A* ceases until the lowering of the fuel in the carburetor opens the inlet valve needle. Spring *P* is not a part of the operating mechanism but is merely for the purpose of keeping the rocker arm *D* in contact with the eccentric *H* to eliminate noise.

Windshield Wiper Vacuum Pump. The operation of the vacuum pump unit is as follows. The rotation of the camshaft eccentric operates the rocker arm *D*, Fig. 9, pivoted at *E*, which pushes the link *F* and in turn the diaphragm *R* downward, expelling the air in chamber *T* through the exhaust valve *U* and opening *X* to the intake manifold. On the return stroke of the rocker arm *D* the spring *S* moves the diaphragm *R* upward, creating a suction in the chamber *T*, opening intake valve *V*, drawing air through inlet passage *W* from the windshield wiper. When the windshield wiper is not being used, the manifold vacuum holds the diaphragm *R*

VACUUM PUMP TROUBLE CHART

Trouble	Evidenced By	Remedy
Vacuum pump unit not operating	Slow action of windshield wiper at high speed or when accelerating	Check wiper valve lines and fittings. If trouble is not located, disassemble vacuum pump unit and check valves and diaphragm
Punctured vacuum pump diaphragm	Oil smoke in engine exhaust. Disconnect line between pump and manifold, at pump, and hold paper in front of pump opening and check for oil spray in exhaust from pump	Replace vacuum pump diaphragm
High gas pressure or noise	Gas pump link striking upper diaphragm protector of vacuum pump	Replace rocker arm pin and vacuum pump link
Noise	Worn vacuum pump link and rocker arm pin	Replace link and rocker arm pin

downward against the spring *S* so that the diaphragm does not make a complete stroke for every stroke of the rocker arm *D*. When the manifold vacuum is greater than the vacuum created by the pump, the air will flow from the windshield wiper through both valves of the pump and the operation of the wiper will be the same as if the pump were not installed. However, when the intake manifold vacuum is low, that is, when the car is accelerating or operating with widely opened throttle, the vacuum created by the pump will be the greater and will operate the wiper.

Repairs Made without Disturbing Fuel Pump Installation. First of all make certain that the trouble is in the fuel pump. If there is evidence of a lack of fuel in the carburetor or the carburetor is flooding, check the float and needle valve for proper functioning. Examine the gas line for leaks, split seams, kinks or obstructions. Loose pipe fittings should be checked. Tighten all pipe connections at the gasoline tank and at the pump. Make certain that the cork gasket of the glass bowl is flat and unbroken, then tighten the retaining nut. Remove the glass bowl and clean the screen. Tighten the valve plug, replacing the valve plug gasket if necessary. Leaks at the diaphragm flange are remedied by tightening the cover screws alternately and securely.

Check if leak occurs at pipe fittings, thus allowing the fuel to run down the pump to the flange and appearing to originate there. Do not use shellac or any other adhesive on the diaphragm. Replace sticking or warped valves. Be sure that there is no dirt or foreign matter on the valve seat. A drop of light oil on a new valve before installing will assist in first priming. Use a new valve plug gasket when reassembling.

Testing. Due to the strength of the spring used in the vacuum pump unit, it is not practical to attempt a bench test of the completed pump in case it has been rebuilt. The fuel supply section of the pump should be tested when the assembly of that section is completed. The only practical test for the completed combination fuel and vacuum pump is on the engine.

Re-install the completed pump on the engine. To check the performance of the vacuum pump unit, open the windshield wiper valve and observe the performance while alternately idling and accelerating the engine. The operation of the windshield wiper

should be reasonably constant, regardless of the engine speed or throttle opening.

When reinstalling the pump, be sure that the push rod is at the inner end of the stroke and use care in pulling up the mounting bolts evenly. If this point is neglected, distortion of the pump flange may result because of the heavy spring used in the vacuum pump unit. Be sure the gasket is used between the pump and the crank case. Never operate the pump with the outer passage of the vacuum pump unit closed with a plug of any sort. The downward or exhaust stroke of the pump is positive and the mechanism may be damaged if this caution is neglected.

Service Hints. Never stretch or in any way change the tension of the valve spring as this will change the pressure of the spring against the valve and reduce the capacity of the pump, particularly under extreme conditions. Always use new valve springs if the old springs are at all questionable. Do not replace the fibre valves with make-shift valves, such as steel balls, metal discs, etc. The fibre valve has proved superior to all other types of valves under all conditions.

Do not distort the diaphragm. In every instance, use a special spanner wrench to hold the hexagon alignment washer stationary while tightening the pull rod nut. This will prevent distortion of the diaphragm which distortion would cause leaks or poor performance. Make certain that the ends of the lock washer under the pull rod do not overlap. This would prevent tightening the nut evenly and securely.

Gum in Gasoline and Sticking Valves. In some cases, fuel pump operation has been impaired due to a gum-like substance forming on the valves and making it impossible to operate properly. Investigation has shown that this gum is contained in some fuels, particularly in cheaper so-called cut-rate brands. When this trouble is encountered in connection with the fuel pump, it is necessary to thoroughly clean and polish the pump valves, valve seats, and gas strainer parts to insure correct operation of the pump. It is possible that the trouble will be overcome with a different grade of gasoline.

Fuel Filter. The fuel filter is an integral part of the fuel pump. It comprises a glass bowl with a screen of fine mesh, through which the fuel must pass upward. Dirt and water settle in the bowl which

may be easily removed for cleaning. It is important that the screen be inspected and the bowl cleaned frequently to reduce to a minimum

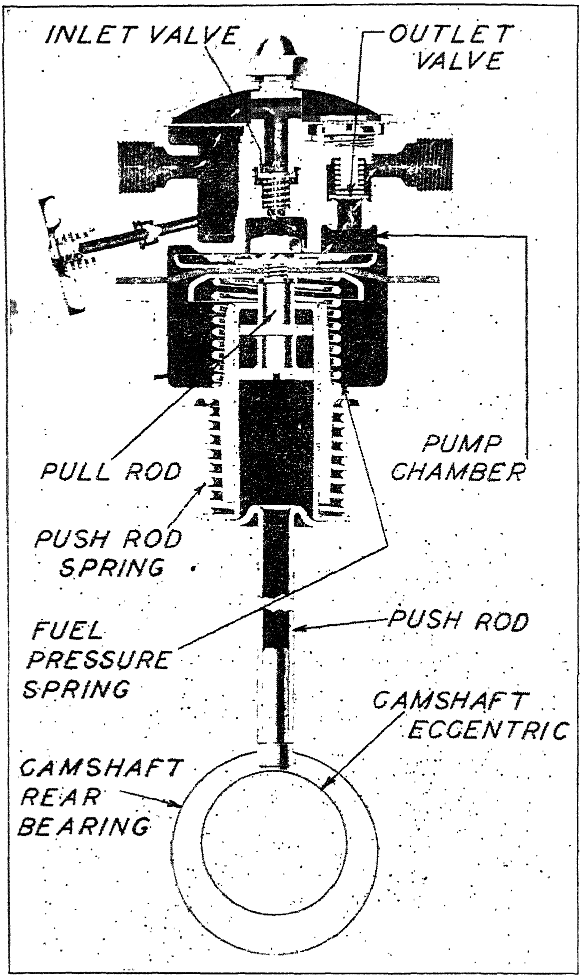


Fig. 10. Ford "V-8" Fuel Pump

the chances of dirt being forced through into the fuel pump valves and carburetor jets. Unless the screens in the fuel system are kept clean, the fuel system will eventually fail.

FORD "V-8" FUEL PUMP

The Ford "V-8" fuel pump, Fig. 10, is of the diaphragm type and is located behind the carburetor on the top of the engine. This pump is operated by a push rod, which makes contact with an eccentric on the camshaft. The operation of the pump is entirely automatic and needs little attention outside of keeping the screen free from dirt and the pipe connections tight. Should the carburetor not receive sufficient gasoline, it may be caused by either no fuel in the tank, the screen being clogged with dirt, or the gasoline line having a leak somewhere in the pipe or its connections.

After a period of service, it is possible that the diaphragm which draws the gas from the tank will become worn and allow gasoline to go down into the chamber below it. At the bottom of this chamber is a small hole, and gasoline leaking from this hole indicates trouble in the diaphragm, which should be replaced as soon as possible.

In the case of some of the earlier models of the Ford "V-8" pumps, trouble developed owing to the lack of lubrication of the push rod. Later models utilized the vapor from the valve compartment to provide lubrication and prevent rust, due to vapor condensation.

AIR CLEANERS

Pontiac Fuel and Vacuum Pump. The combination of a fuel and vacuum pump operated from the same lever and cam on the camshaft is common practice in many cases. The fuel pump is designed to provide a constant flow of fuel to the carburetor, and the vacuum pump is designed to provide a uniform vacuum for operation of the windshield wiper. Thus, we have established as between the vacuum pump and the windshield wiper vacuum control in ratio to the engine speed. It will be noted in Fig. 11 that a rocker arm *A* is operated from the eccentric. The rotation of this eccentric on the camshaft causes the rocker arm *A* to be forced downward and this in turn through its contact with the lever *B* causes the link *C* to be raised and this in turn through its connection, raises the diaphragm *D*. As this diaphragm *D* moves upward against the spring pressure *E*, vacuum is created within the pump chamber *F*. This is the suction stroke of the fuel pump and serves to draw gasoline from the supply tank at the rear of the car through the inlet *G*, at which point it enters the sediment bowl *H* and then

passes on through the strainer I and finally through the inlet valve into the pump chamber F. As the eccentric continues to move, spring pressure E is allowed to push the diaphragm D downward and force the fuel which has been trapped in the chamber F through the outlet valve J and so on through the fuel outlet and the fuel line to the carburetor.

This pumping action continues as long as there is a demand in the carburetor, but when the carburetor float valve lifts on the incoming fuel and cuts off the supply line, a pressure is created in the pump chamber F. This pressure will serve to hold the diaphragm D upward against the spring pressure E where it will remain in-

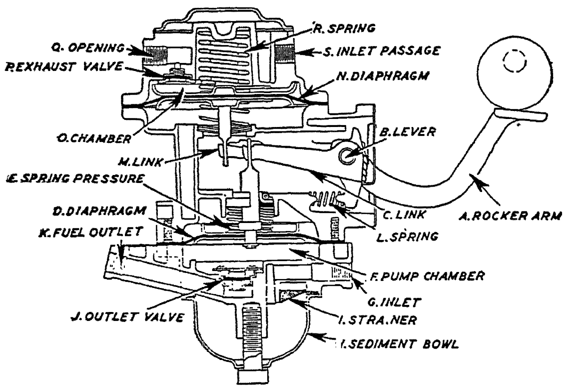


Fig. 11. Pontiac Fuel and Vacuum Pump
Courtesy of Pontiac Motor Company

operative in the upward position until such time as the carburetor requires further fuel and the spring forces the diaphragm down, starting the cycle of the pump operation over again. A spring L is provided to operate against the inner end of the rocker arm A in such manner as to keep the outer end of the rocker arm A in constant contact with the eccentric.

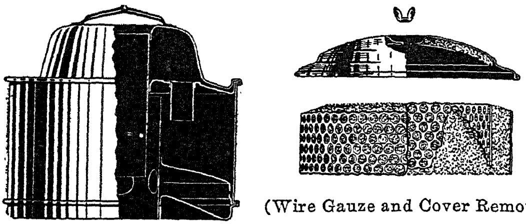
Operation of Vacuum Section. As mentioned above, the vacuum section is part of the fuel vacuum pump. The initial operation again comes from the camshaft eccentric as it forces the arm A downward, this arm being pivoted at B, and this in turn pushes the link M and that in turn causes the diaphragm N to move upward, expelling the air in the chamber O through the exhaust

valve P and out the opening Q to the intake manifold. This same movement induces further pressure on the spring R so that when the arm A is on its return stroke, the diaphragm N moves downward and creates a suction in the chamber O, which serves to open the intake valve and draw air through the inlet passage marked S from the windshield wiper. The windshield wiper is connected by means of a line of small tubing. Unless the windshield wiper is in use, the manifold vacuum will serve to hold the diaphragm N upward against the spring pressure R so that the diaphragm does not make a complete stroke for every stroke of the rocker arm A. When the manifold vacuum is greater than the vacuum created by the pump, the air will flow from the windshield wiper through both valves of the pump and the operation of the windshield wiper will be the same as if the pump were not installed. However, when the intake manifold vacuum is low, that is, when the car is accelerating or operating at high speeds, the vacuum created by the pump will be greater and will serve to operate the windshield wiper at a normal and proper speed.

Pump Troubles. In the main the operation of all of the AC fuel pumps is quite similar, and inasmuch as rather specific direction has been given for checking on possible faults, only brief trouble hunting instruction for the Pontiac is given here. Always make certain that the trouble is in the pump before starting to work on it. If it is determined that the trouble is in the pump, then check all gasoline tubing or pipe connections both at the gas tank and at the pump. Remove and clean the screen. If the pump is leaking at the diaphragm, tighten the screws and examine the pump for visible failure as might be seen in the case of a broken rocker arm or defective or worn links. A broken spring would cause failure to pump. A diaphragm which was punctured or worn out, of course, would show fuel leakage through the vent hole in the body and the remedy is obvious.

In case the vacuum pump is not operating, it will be evident by slow action of the windshield wiper at high speeds or when accelerating the engine. First check the wiper valve lines and fittings to see whether there is a leak. If the trouble is not located, it will be necessary to disassemble the vacuum pump and inspect for trouble. In case the vacuum pump diaphragm is punctured, there

will be evidence of oil smoke in the engine exhaust, in which case disconnect the line between the pump and the manifold at the pump. Hold a paper in front of the pump opening checking for oil spray in the exhaust from the vacuum pump. In case puncture does exist, it will be necessary of course to replace the vacuum pump



(Wire Gauze and Cover Removed)

Fig. 12. Buick Series 40 Air Cleaner
Courtesy of Buick Motor Company

diaphragm. In case of undue noise from the unit, it may be that the vacuum pump link and rocker arm pin are worn, in which case replace them. Under no circumstances should any of the springs have their tension changed. If the value of any spring is questioned, it is suggested that new ones be installed. It is further suggested

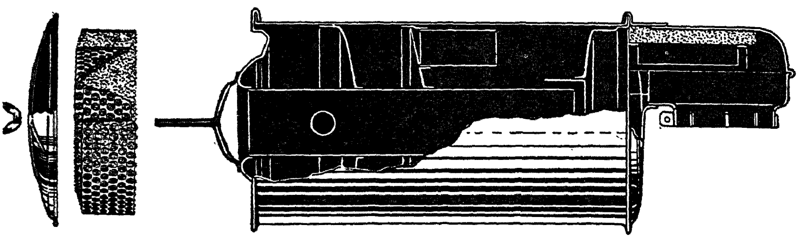


Fig. 13. Buick Series 60-80-90 Air Cleaner (Regular)
Courtesy of Buick Motor Company

that no attempt at repair be made with reference to the fiber valve inasmuch as these fiber valves have proved superior to all other types.

Air Cleaner and Flash-Back Preventer. Practically all automobiles are fitted with air cleaners which are designed to serve also as air intake or carburetor silencers and as flash-back preventers to arrest the flame in case of back fire before the flame has had opportunity to do any damage.

Buick Air Cleaners. Fig. 12 illustrates the 1937, Series 40, Buick air cleaner. Fig. 13 illustrates the regular air cleaner used

for Series 60, 80, and 90 Buick. In all views the cleaners are shown in partially disassembled states so as to illustrate the nature of construction. Cars which have been delivered in the territories where the dust conditions are general are equipped with what is known as a heavy-duty air cleaner, these cleaners being quite similar in appearance to the standard cleaners; however, they are marked as heavy-duty air cleaners. When the heavy-duty cleaner is in-

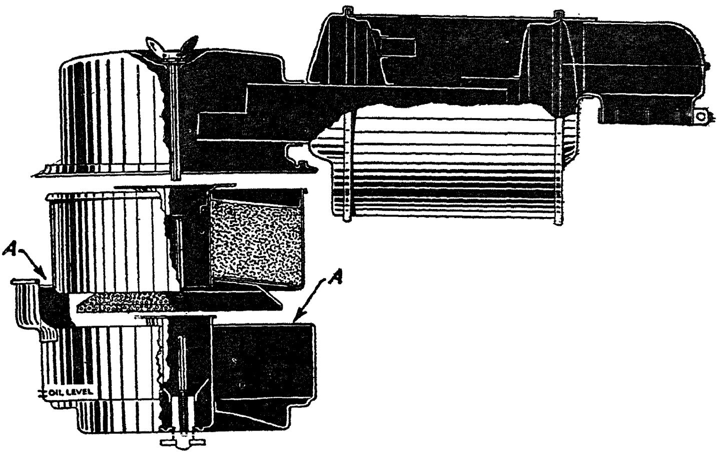


Fig. 14. Buick Heavy-Duty Air Cleaner
Courtesy of Buick Motor Company

stalled at the factory, certain carburetor calibrations which work satisfactorily with the heavy-duty cleaner are also installed at the factory.

Air enters the copper mesh cleaning element in case of Fig. 12 or Fig. 13. It is divided into small streams and thus exposes dust to the oil-covered surfaces. This dust then clings to the oil, leaving the air clear as it enters the engine. This same copper mesh element also acts as a flame arrester in case of back fire. In order to quiet the air intake, resonance chambers are provided and lined with felt pads. The design is such as to quiet the intake sound. In case of the heavy-duty intake silencer and air cleaner illustrated in Fig. 14, the air and dust enters at *A* and passes down into the lower chambers through a narrow passage, which causes it to attain a high velocity and as it strikes the oil bath at the bottom of the cleaner, certain of the heavier particles of dust are thrown

out of the air stream and caught by the oil bath. Some of the air is brought in direct contact with the oil and thus washed free of dust. The operation also serves to cause some of the oil to be picked up in the form of spray and carried into the copper gauze. As the air passes over the copper gauze, dirt, which is in the copper gauze, is deposited on the oil.

The dust is being washed constantly from the copper gauze by the oil which is being picked up. For instance, as the throttle is opened and the air velocity increased, oil is picked up from the pump and carried into the cleaning element. Then as the throttle is closed or the car is slowed down, the excess oil which has been deposited on the copper gauze is returned to the oil sump, washing away the dust accumulation and carrying it with it. By this method a continuous washing action is secured with each opening and closing of the throttle.

Servicing the Regular Silencers and Air Cleaners. The cleaning element should be removed from the cleaner by means of unscrewing the wing nut and removing the cover assembly, after which the copper gauze cleaner may be removed. It is not necessary to remove the unit from the engine. The copper element should be washed by dipping it several times in gasoline or kerosene until it has been washed clean. After it has been dried out, it should be re-oiled by dipping it in No. 50 S.A.E. oil and allowing the excess oil to drain off. Use care to see that the oil does not get onto the felt pad in the cover.

Servicing Heavy-Duty Silencer and Cleaner. Under normal circumstances it would be advisable to wash the heavy-duty cleaner each two thousand miles. Where extreme dust conditions are encountered the cleaner should be washed more frequently. In order to wash the cleaning element, remove the section of the cleaner containing the oil supply. Wash this unit carefully with gasoline or kerosene. Next, remove the wire gauze assembly and wash thoroughly by dipping it into gasoline or kerosene. Allow the cleaning element to dry naturally. Do not blow air from the air hose into it and do not dip the wire gauze element into oil before reassembling. After the unit has been cleaned and reassembled, fill the oil sump with one pint of No. 50 S.A.E. oil and reassemble the air cleaner on the engine.

SUPERCHARGERS

A great many engineers in the automotive industry have visualized the time when superchargers would be in general use in connection with automobile engines. The supercharger has gone through a great variety of experiments and a number of designs have been evolved. The most important use served by superchargers is in altitude flights with a plane where it is necessary to have considerable quantities of the rarefied atmosphere forced into the engine cylinders in order to bring the compression ratio up to a point where sufficient power will be developed to handle the plane in the rare element in which it is flying.

In America, the demand for the supercharger is relatively slight when its use in connection with automobile engines is considered. In the foreign countries, the use of the supercharger is more in line with the demand for the simple reason that in many of the foreign countries taxes are almost prohibitive for the large bore engine. Accordingly, in order to secure a properly performing engine with a low-piston displacement, the supercharger, which will force additional air into the same size bore and thus result in increased power, plays a rather important part in the design of the automobile as a whole.

In America, the reverse is true since the tax in America, generally speaking, is not prohibitive. Horsepower rating for licensing automobiles is figured according to the bore of the engines. If the bore is decreased, the tax is likewise decreased. The decrease in the bore with its attendant decrease in power led to the adoption of the supercharger in some of the foreign cars. The most important part played by the superchargers in America have been with reference to the racing cars of the very small bore, such as were formerly required for use in the big time races, sponsored by the Contest Board of the American Automobile Association. Over a number of years the piston displacement was steadily decreased until finally an allowance of $91\frac{1}{2}$ cubic inches was the maximum.

One of the most surprising features with reference to these very small racing engines was the fact that they would develop approximately 160 horsepower by means of the supercharger, which gave an extremely high r.p.m. The power curves in the center view of Fig. 15 were developed as a result of tests run in the laboratory of

the A.C. Spark Plug Company. It will be noted that while the horsepower of the unsupercharged engine fell off at approximately 60 horsepower, the curve on the supercharged engine ran up to a peak of 140 horsepower or more.

Supercharged Two-Cycle Engines. The two-cycle engine has always been popular as a marine job and in certain cases has been used in the automobile field. Experiments calculated to make use of the supercharger as a fuel induction device in connection with the two-cycle engines are being pursued at different points in the country. It is anticipated that superchargers will have a very direct bearing upon the final development of the two-cycle engine.

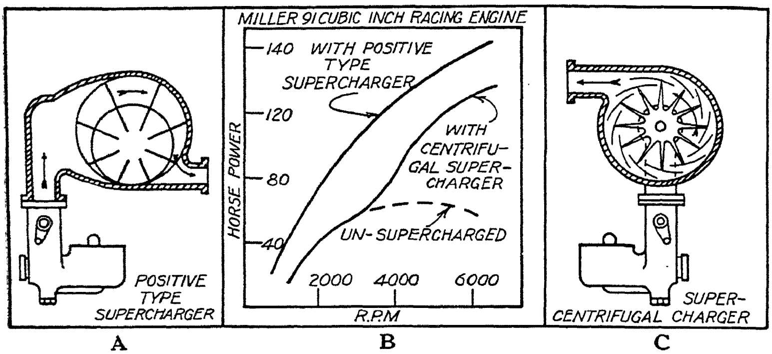


Fig. 15. A—The Vane or Positive Type of Supercharger
B—Graph Showing Power Curves of a Miller Racing Engine
C—The Centrifugal Type of Supercharger

An engine on the race track at Indianapolis in one race was of the eight-cylinder ninety-one cubic inch displacement type. A rotary valve was used at the base of the cylinder in connection with the supercharger as a means of induction. The engine gave a very good account of itself. It was the development of Fred Duesenberg of the Duesenberg Factory at Indianapolis.

Principle of the Supercharger. The performance of the supercharger is that of taking the air, at normal atmospheric pressure, drawing it through the carburetor, and then compressing it with the gasoline charge and forcing it into the engine. In some instances, the supercharger draws the air from the outside and forces it through the carburetor and thence on into the engine. The principle back

of the use of the supercharger is the induction of fuel at a higher pressure than that which could be obtained with normal atmospheric pressure.

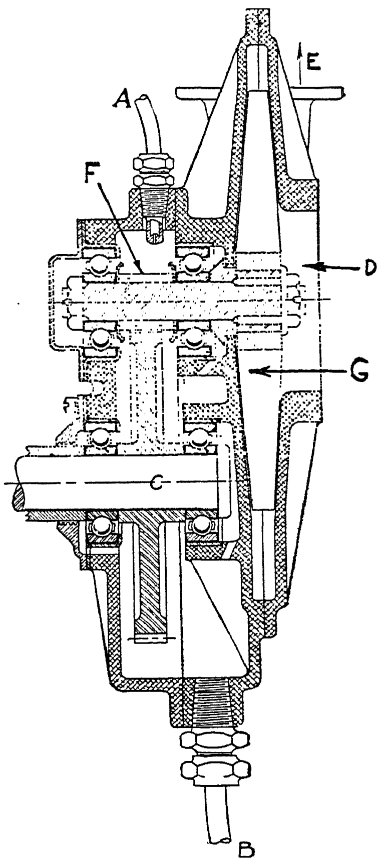


Fig. 16. Internal Construction of a Popular Racing Car Supercharger, Used on the Miller and Duesenberg Racing Cars

G is the impeller, *D* is the air inlet, and *E* is the outlet. *C* is the shaft which is used to connect the shaft to the engine and *F* is the high-speed pinion on the impeller shaft. *A* is an oil inlet and *B* is an oil drain tube.

It is claimed that some of the small racing cars which have made speed records up to 173 miles per hour, with the ninety-one cubic inch engines, use superchargers driven at speeds of 40,000 revolutions

per minute. The superchargers used in connection with these engines were generally of the centrifugal type, Fig. 16, and, as a rule, were driven about five times engine speed. These very small engines would turn up to 6,000, 7,000 and 8,000 r.p.m. so that the top speed for the supercharger was very likely 40,000.

The pressure induced by a supercharger of this type is about 27 pounds per inch. From this figure it will be seen that it is quite possible to force a very much larger charge of fuel and air through the valve opening for the very short time during which the valve is open, with the result that such records as above recited are possible.

Supercharger Design. There are three general types of super-

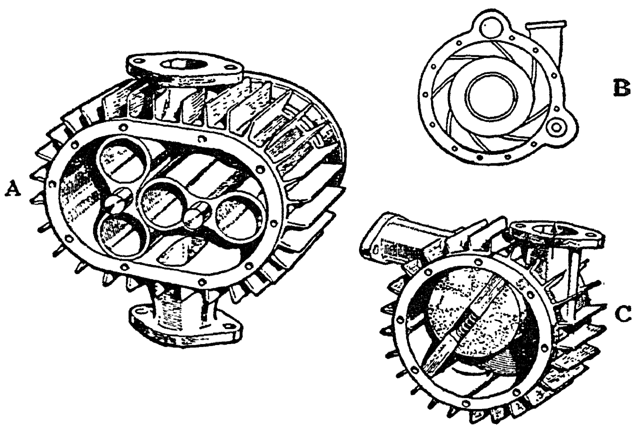


Fig. 17. A—Roots Type Blower Supercharger
B—Centrifugal Type Supercharger
C—Vane Type Supercharger

chargers in use. In American racing circles, the most popular type is the centrifugal type. One of these is shown at *B* in Fig. 17 and another one at *C* in Fig. 15. In the latter case the carburetor is shown connected to it. The centrifugal type of supercharger operates just the same as the centrifugal type of water pump on an automobile. The air is admitted at the center of the supercharger and, due to the centrifugal force developed by the very rapidly rotating blades, the air is thrown off to the side and a pressure developed which forces it out of the outlet and thence on through the intake manifold and past the valves into the piston chambers of the engine. The centrifugal type of supercharger is termed the non-positive type, since

it is dependent upon the weight of the air and the centrifugal force to get the desired results.

The vane type of supercharger is of the positive type. One of these is shown at *C* in Fig. 17 and another one is shown at *A* in Fig. 15. The action of the vane type of supercharger is very similar to the action of a vane type oil pump used in connection with automobile lubrication, a good example of which was the four-cylinder Dodge pump, popular from 1918 to 1926.

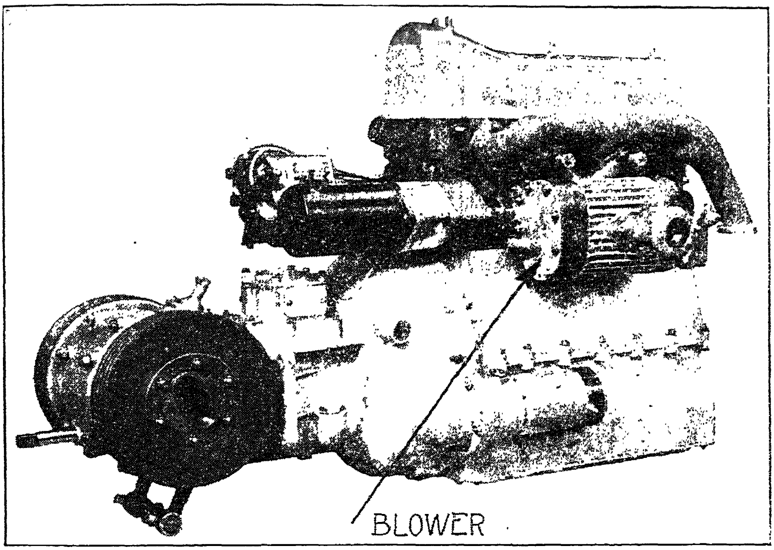


Fig. 18. The Alvis, an English Car, Makes Use of the Roots Blower-Type Supercharger
The Alvis is a front wheel drive car.

In action, this device works by pulling air in at the inlet side, forcing it ahead of a vane, and gradually crowding it into a smaller space and forcing it out of the outlet. The arrows in Fig. 15 indicate this method. It will be noted that in the use of the vane type, the vanes or blades slide in slots or grooves in the hub of the device so that the vanes are constantly in motion, moving into or out of the hub. A spring action serves to keep the vanes thrust against the outer wall of the supercharger housing.

Another positive type of supercharger is that known as the Roots blower type. One of these is shown at *A* in Fig. 17 and another

one is shown mounted on the side of the Alvis engine in Fig. 18. The Roots blower operates on the same principle as the gear type pump. Air is drawn in through the inlet side by the action of the rotating elements in the pump housing. It is then compressed on the opposite side of the rotating elements and forced out and into the intake

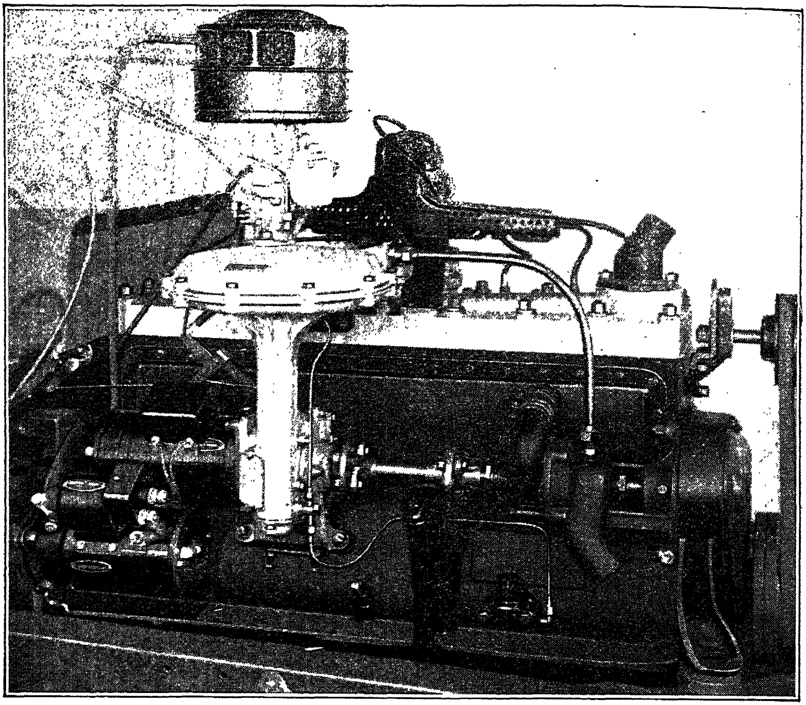


Fig. 19. 1934 Graham "Eight" Engine
The supercharger provides forty-two per cent increase in horsepower, giving improved performan ; at all driving speeds.
Courtesy of Graham-Paige Motors Corporation

manifold and engine combustion spaces. The advantage of this type of supercharger is that its speed has a fairly direct relation to the amount of air being displaced. In the case of the centrifugal type of supercharger, its action depends upon the speed and weight of the air, being non-positive. In the Roots blower, the action is rather positive so that it is possible to have better and more uniform fuel mixture provided. The adjusting of the fuel mixture in relation to the air flow from a supercharger is a very delicate one.

GRAHAM SUPERCHARGER

The Graham supercharger, Fig. 19, is of centrifugal type which supplies power to the feeding of the fuel mixture into the engine cylinders. Instead of having the engine dependent upon its natural pumping or sucking action to draw the mixture through the car-

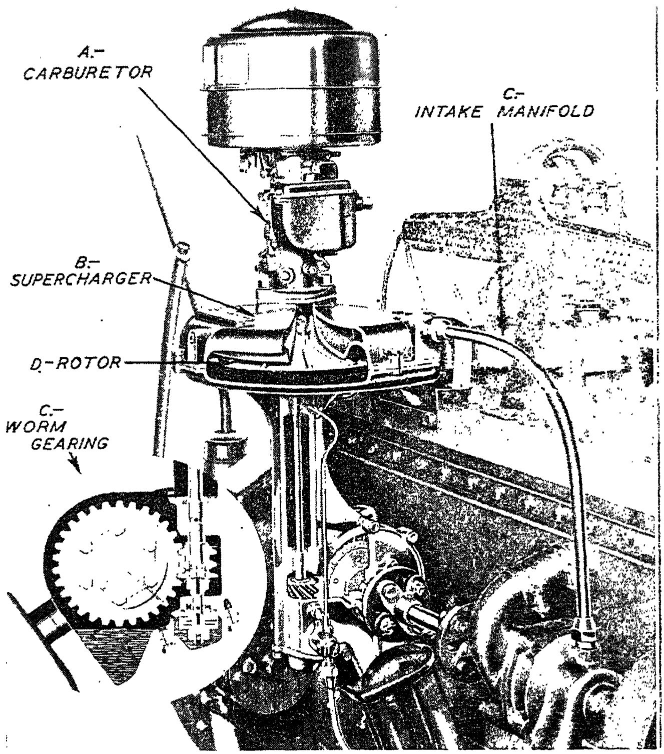


Fig. 20. Graham Supercharger in Sectional View

buretor and into the combustion chambers, the supercharger forces the mixture into them under pressure. The suction of the engine is replaced by pressures ranging from one to several pounds. Under full throttle, the manifold pressures are positive at all engine speeds. Since with a non-supercharged engine a negative pressure (vacuum) ranging from one to several pounds is required to draw the mixture into the cylinders, the effect of the supercharger is actually much

greater than any gauge pressure reading would indicate. Several pounds of vacuum is replaced by several pounds of pressure, approximately twice the amount, in fact.

The supercharger *B,* Fig. 20, is of the centrifugal or "blower" type and is mounted between carburetor *A* and intake manifold *C* of the engine. It consists primarily of a casing within which rotor *D,* similar in form to that of a vacuum sweeper, revolves at speeds up to approximately 30,000 r.p.m. The centrifugal action of the rotor draws mixture of fuel and air from the carburetor into center of casing and expels it under pressure at the rim or edge, forcing it through intake manifold to combustion chambers of the engine.

The carburetor is mounted directly upon the supercharger rotor cover and is of the down-draft type. After passing through the supercharger, the fuel mixture is carried over the top of the engine through a tube connected to the intake manifold, which is similar in type to that used on Graham standard engines. Thence, it is forced under pressure into the combustion chambers.

The lower part of the unit consists of a gear case enclosing worm gearing especially developed for driving centrifugal superchargers. The worm wheel is driven from the accessory shaft which has a ratio of .2 to 1 with the crankshaft. The worm gearing, Fig. 20, itself has a ratio of 4.8 to 1. Thus, the rotor revolves 5.75 times engine speed, or 23,000 revolutions per minute at the horsepower peak speed of 4,000 revolutions per minute. The rotor *D* is 7.5 inches in diameter and, with its shaft, is accurately balanced and tested to run smoothly.

Simplicity of Graham Supercharger. Both the rotor and the worm wheel shafts are mounted on plain bearings. Complicated bearing mountings and adjustments have been completely eliminated. The unit has been so designed as to make it just as much a part of the engine as the lubrication or cooling systems. No adjustment of either the bearings or the worm gearing is required.

Full Pressure Lubrication. All the bearings and the worm gearing of the supercharger are full-pressure lubricated by the same oil used to lubricate the engine. A reserve supply of oil is automatically retained within the worm gear casing to assure adequate lubrication of the gears and bearings during the starting and warming-up period. The cover which forms the top half of the rotor casing is water-jacketed. No exhaust heat is required to warm the mixture.

There are no hot spots on the intake manifold. The cooling water controls the mixture temperature at desirable levels under partial and full-throttle operating conditions.

Uses Leaner Mixture. By placing the supercharger between the down-draft carburetor and intake manifold, the rotor scrubs and thoroughly mixes the fuel and air after it is taken in a relatively raw condition from the carburetor. Obviously, the high-speed rotor is a most effective means of putting the mixture in a most explosive condition before it reaches the cylinders. The result is that since the supercharger begins to operate the instant the engine begins to be rotated by the starter, the mixture is in better condition for quick starting in cold weather. No slugs of fuel can pass the rapidly whirling rotor. It is a most effective mixing device.

A more important result from the standpoint of operating economy, is that since the mixture is continuously churned by the rotor at all engine speeds, it is never necessary for the engine to require more than the most efficient and power-giving amount of fuel. A rich mixture is never needed. The supercharger, by its thorough vaporization of the fuel, makes it possible for the engine to operate on a leaner mixture than ordinarily. Even with exceptionally lean mixtures the supercharger so completely prepares it for the engine that backfiring (which usually results from excessively lean mixtures) is almost an impossibility. The supercharger consumes less than two horsepower. By consuming this small amount, it in turn enables the power of the engine to be tremendously increased. This small consumption of power is due to the fact that the supercharger, by forcing the mixture into the cylinders, offsets the necessity for the engine to pump or suck it into them.

All automobile engines are relatively inefficient in the operation of pumping the mixture into the cylinders. This is due to the large clearance volume (in this case the combustion chamber) and other technical reasons. The fact that the supercharger is efficient as a means of offsetting this pumping loss, is, that although it requires from 5 to 6 horsepower to drive the supercharger at 3,000 revolutions per minute engine speed when disconnected, the amount required when it is supplying it with mixture is 1.8 horsepower at the same engine speed. Indicative also of the gain in efficiency of the engine when equipped with the supercharger, is the fact that the thermal

efficiency is about 21 per cent from 2,000 to 3,000 revolutions per minute engine speed, decreasing above and below this range; the efficiency of the supercharged engine remains above 19.5 per cent until a speed of 4,000 revolutions per minute is attained. At this speed the thermal efficiency of the non-supercharged engine has dropped to 16 per cent.

Acceleration. While the supercharged engine does develop much more power, this alone would not necessarily make the engine accelerate faster at from 50 to 60 miles per hour than at 25 to 30 miles per hour. Herein lies one of the most unusual facts relating to the action of the supercharger. The factor in an engine which gives the car greater acceleration is the torque or twisting force on the crank shaft. The greater this is, the faster the acceleration. Also, if it is greater at one speed than another, the acceleration in turn will also be faster. This is exactly why the supercharged engine gives the car such fast pick-up at twice the car speed at which it is ordinarily greatest.

The supercharged engine delivers not only more torque at car speeds around 25 miles per hour thus making it have faster get away, but it also delivers its maximum torque at twice the speed of the ordinary engine. Instead of delivering its greatest torque at 1200 revolutions per minute, as is usually the case, it delivers it at 2400 revolutions per minute and, for this reason, the supercharged engine can pull harder and faster than the non-supercharged engine which begins to level off and gradually increases its speed. The supercharged engine seems to have no top speed when the throttle is pushed to the floor at from 50 to 60 or even more miles per hour.

Graham Dual=Phase Throttle for Controlling Acceleration and Speed. The dual-phase throttle is simple to operate. By depressing the foot accelerator to a certain degree, the effect of the engine without supercharger is given. The maximum downward position in this first phase is controlled by a relatively softer spring than that used in the second phase. In addition, the amount of pedal travel for a given rate of acceleration is longer than in the second phase. This prevents the driver from inadvertently opening the throttle too far. The second phase of throttle opening is obtained merely by depressing the pedal farther against just enough additional spring resistance for the driver to feel the difference in pressure. It is only necessary

to press the pedal all the way down to obtain the full power and accelerating ability of the engine.

Since the supercharger is in operation at all engine speeds, the action of the dual-phase throttle is one of adjusting it to a position (as determined by the double springs), wherein the first amount of opening is sufficient to give the same power as that derived from the standard non-supercharged engine at the same engine speed. This makes possible a comparison between the engine with and without the effect of the supercharger.

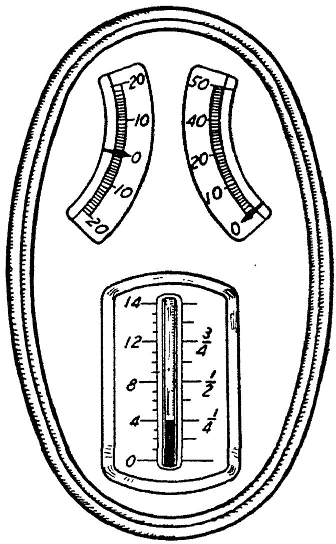


Fig. 21. Head of K-S Telegage

K-S TELEGAGE

The head, shown in Fig. 21, is mounted on the instrument board. It is simply a U-shaped tube containing a heavy, red liquid. The front half of the U-shaped tube is of glass open at the top and the back half of brass. The air line is connected at the top of the back part of the tube. Any pressure which comes through the air line will press the liquid downward in the back part of the tube and upward in the front part of the tube. In fact, the difference in the levels of the

liquid in the two halves of the tube is an exact measurement of the pressure coming through the air line.

To have the gauge read correctly, three things are necessary. First, the head must read exactly empty or zero when disconnected. Second, the air line must be free from leaks or obstructions. The most common obstruction is gasoline, which, however, can only be driven into the line when connections are not properly made. Third, the connections must be tight at both tank unit and head. If the instructions given above are followed, the liquid in the head will always indicate accurately the quantity of gasoline in the supply tank. A

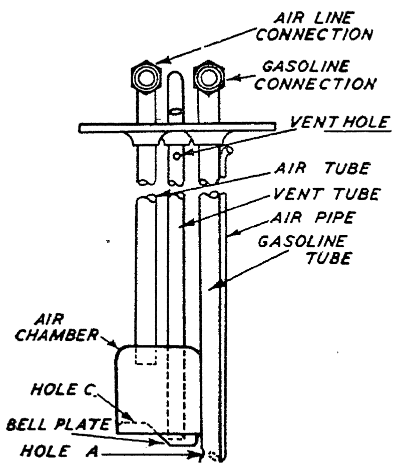


Fig. 22. Tank Unit

leak anywhere in the line, will, of course, prevent the quantity being accurately measured.

Note. In the head, as shipped for service, the liquid is in the back tube and is held there by the sealing plug at the top. When the plug and cap are removed, the liquid will seek the same level in both tubes. Do not lay the head down after removing the plug as the liquid will be spilled from the top of the glass tube. It is advisable to first clamp it in place on the instrument board.

Reserve. The Telegage provides a reserve of approximately $\frac{3}{4}$ inch of gasoline, that is, the bottom $\frac{3}{4}$ inch in the tank never shows on the gauge. The actual quantity of gasoline in the reserve

varies from $\frac{3}{4}$ to $1\frac{3}{4}$ gallons, depending on the shape and size of the tank. Above this point, the gauge reads exactly, gallon for gallon, all gasoline put into the tank.

Operation. The tank unit is shown in Fig. 22. When the installation is operating properly, the air line, air tube, and air chamber above the level of the hole *C* are filled with air. The gasoline tries to rise to the same level in the tank unit as it is in the tank. It therefore exerts a pressure through the hole *C* on the air within the air chamber. This pressure is communicated through the air tube and air line to the head on the instrument board, where it is recorded by the rise of the red liquid in the glass tube.

The vent tube, open at the top, is merely a safety valve which protects the gauge against high pressure. It does not enter into the operation of the gauge in any way. The remainder of the tank unit, that is, the gasoline tube and air pipe, act only as a means of supplying fresh air to the air chamber. This overcomes the loss of air due to absorption in the gasoline and contraction of the air due to a sudden drop in temperature. Thus the air tube and air chamber are always kept filled with air.

The air supply mentioned above is obtained in the following way. Every time the vacuum tank sucks gasoline through the gasoline tube, it draws a small quantity of air down the air pipe and into the flow of gasoline. When the vacuum tank stops drawing and the gasoline in the pipe runs back into the tank, it carries with it these bubbles of air which rise under the bell plate. If any gasoline has collected in the air chamber, the air passes up through hole *C* to replace it. When the air chamber is full of air, these bubbles pass off without being used.

Repair Instructions. The person making the repair should do what is here set down for his guidance, or he will likely not get satisfactory results. The gauge should be intact, that is, not broken or with any part missing, but having had one or more things happen to it which need to be corrected. Do not remove the head from the instrument board or start putting on new units until you have studied the following instructions.

Remove the tank filler cap, seeing that the vent cap is open. Disconnect the air line (gauge line) at the front end from the gauge head. Make the gauge read exactly zero (empty). Liquid may be

added or removed where the air line comes off. In adding liquid use a medicine dropper, being careful not to overfill. To remove the liquid, hold a toothpick or match in the brass tube to absorb a small quantity. Use only K-S liquid, none other will do. Blow out the air line, using a hand tire pump (nothing else will do), and cut the metal connection from the tire pump hose. Push the pump hose securely over the front end of the air line. Give at least 50 good strokes continuously. Reconnect air line, seeing that the air line connections are tight at both ends. Be sure before you connect, that the gauge reads empty and therefore does not leak. Replace the tank filler cap. Make the gauge read by either of the two following methods: Remove the fuel feed line at the top of the vacuum tank and with the mouth blow back into the main tank or, drive the car until the gauge no longer comes up (three to ten miles). The reading thus obtained must remain with the motor dead.

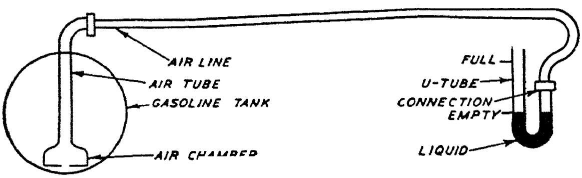


Fig. 23. Diagram Drawing Showing a Simple Telegage Connected with Tank Empty

If the above operations do not correct the trouble, check for a defective unit as suggested herewith. Inspect the connections for dirt and flaws in material. Test the air line for leaks by holding a finger over one end and sucking on the other. If the suction will hold the tongue for one minute, the air line is O.K. See that the tubes and holes in the tank unit are free and open. Blow through the air tube and gas tube and suck on the air pipe. If a defective unit is found, confer with the car dealer or distributor regarding replacement.

The Telegage head must not be adjusted except when the air line is disconnected and then only to bring the top of the red liquid to the "0" or empty mark, Fig. 23. Whenever repairs are made on the Telegage, the air line should be blown out from the front end to clear it of any gasoline which may have been driven into the line when it was disconnected.

CHEVROLET GASOLINE GAUGE

The gasoline gauge is composed of two units. The indicating unit which is mounted on the instrument panel, and the tank unit which is mounted on the gasoline tank. The circuit for this instrument passes through the ignition switch, therefore, the gasoline gauge operates only when the ignition switch is "on."

Operation. When the gasoline tank is empty, current flows from the battery positive through the ammeter to the ignition switch and then to the dash unit top terminal. The current now

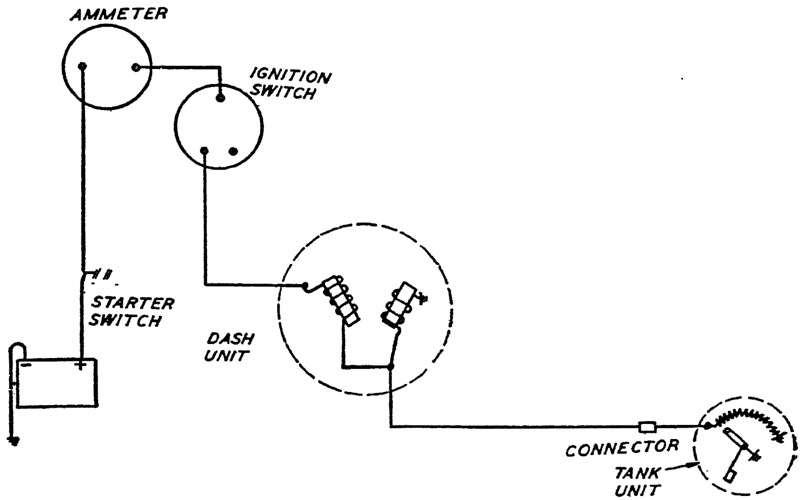


Fig. 24. Chevrolet Electric Gasoline Gauge Circuits

passes through the choke or limiting coil to the common connection between the two coils, which is the lower terminal on the dash unit. At this point, the current is offered two paths, one through the operating coil of the dash unit, and the other over the wire to the tank unit. When the gasoline tank is empty, the contact finger cuts out all the resistance in the tank unit. The largest proportion of the current will pass through the tank unit circuit and only a very small portion through the operating coil of the dash unit, with the result that there is not sufficient current being forced through this circuit to move the hand in the dash unit. If the gasoline tank is half full,

the cork float of the tank unit rises on the gasoline and moves the contact finger over the resistance, cutting resistance into the tank unit circuit as indicated by the lines in Fig. 24.

As the tank is filled with gasoline, more current is passed through the operating coil and the reading of course is higher and as the tank empties, less current is passed through the operating coil and the reading is lower. If trouble is experienced with either the tank or dash unit, replacement of the unit is the only remedy. The following will help in determining the cause of the troubles.

If the dash unit shows empty all of the time, check and make sure that the wire from the ignition switch is tight on the terminals. Remove the wire from the lower terminal, turn on the ignition switch. If the gauge now shows full, the dash unit is O.K. If the gauge still shows empty, the dash unit is at fault and must be replaced. Replace the wire and open the bayonet socket just ahead of the gasoline tank. Turn on the ignition switch. If the gauge now shows full, the wire from the dash unit to the bayonet socket is O.K. but the tank unit is shorted and must be replaced. If the gauge shows empty, the wire from the dash unit to the bayonet socket is shorted and must be replaced.

If the dash unit shows full all of the time, check for loose wire on the lower terminal of the dash unit. Open the bayonet socket, just ahead of the gasoline tank and ground end of wire. Turn on the ignition switch. If the gauge shows full, the wire between the dash unit and the bayonet socket is open-circuited and must be replaced. If the gauge shows empty, the wire is O.K. but the tank unit is open-circuited and must be replaced.

BUICK "AC" GASOLINE GAUGE

The dash unit of this electric gasoline gauge, Fig. 25, consists principally of two coils spaced 90 degrees apart with an armature and pointer assembly mounted at intersections of the coil axis. An inertia dampener is provided on the armature assembly to prevent vibration of the pointer on rough roads. The tank unit is essentially a rheostat, the movable contact of which is actuated by a float that rests on the surface of the gasoline in the tank. Movement of the float is transferred to the rheostat contact arm by a set of gears. A cork washer, held by a calibrated spring between a collar on the

vertical shaft and a stationary lug, acts as a brake. This prevents the slight float movement caused by ripples on the surface of the gasoline from appearing on the dash unit indicator.

When the gasoline tank is empty, the float assembly is at its lowest position where the rheostat in the tank unit is completely grounded. All current through the dash unit then flows through the coil at the empty side of the indicator and the pointer is pulled to the empty mark. As fuel is added in the gasoline tank, the float

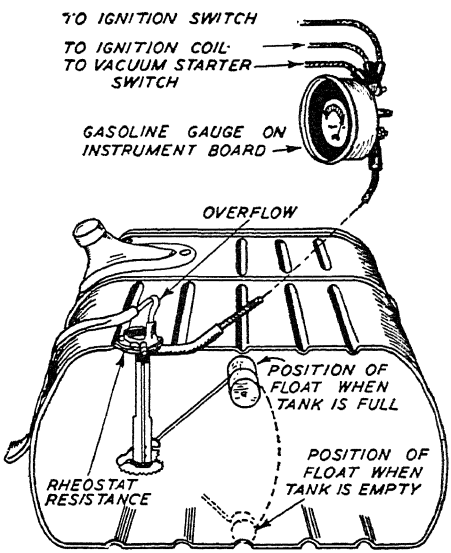


Fig. 25. Electric Gasoline Gauge

assembly rises. This moves the contact brush in the rheostat, introducing resistance into the circuit that grounds the full coil in the dash unit, so that part of the current which flows through this coil and the pointer is attracted away from "empty" to a position of balance between the two coils, its point of rest depending upon the amount of resistance which in turn is governed by the quantity of gasoline that has been added in the tank. The gauge is compensated for temperature variation and is not affected by variation in voltage of the battery. Fig. 26 shows the fundamental electrical circuit of the gauge, and also the magnetic relation of the two coils.

Although the current consumption of the gauge is only approximately .15 amperes, it is connected in series with the ignition switch so that there is no discharge of current when the ignition switch is turned off. The gasoline tank vent has been made a part of the gasoline gauge tank unit assembly.

Removing the Tank Unit. To remove the tank unit, it is necessary to lower the tank. Remove the gasoline tank filler cap and unscrew the filler extension; disconnect the gasoline supply line at the tank, and remove the gas gauge wire from the clip on the cross member; remove two tank support bolts at the front of the tank, and lower the tank on the right side. The wire can now be disconnected

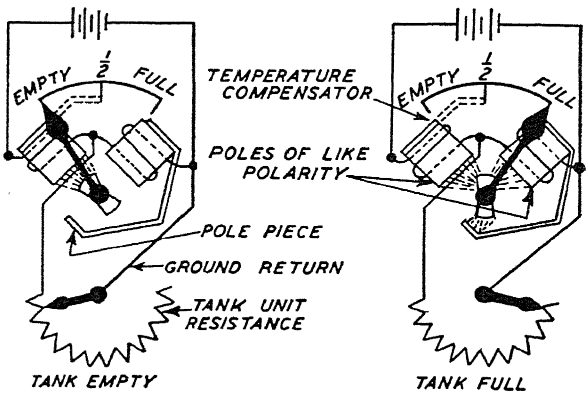


Fig. 26. Buick Gasoline Gauge—Diagram

from the tank gauge unit, and the unit removed from the tank by taking out five screws which hold it in place. It is not necessary to disconnect the tail pipe or tail pipe hangers.

Gasoline Reserve. Gasoline gauges are designed to provide approximately 1½ gallons reserve when the pointer is at the "empty" position. Do not lubricate either the dash or the tank unit. No lubrication is necessary in the dash unit, and the bearings in the tank unit are automatically lubricated by the splash of gasoline. When connecting the wire to the dash unit, make certain that the white wire having black crossing tracers, which leads to the tank unit, does not come in contact with the ammeter connection or th

upper terminal on the dash unit marked "ignition," as this may result in damage to the tank unit rheostat.

Service Suggestions. If the gauge does not register when the ignition switch is turned on, this may be caused by a break in the line between the dash unit and the ignition switch. If the gauge shows "full" under all conditions, this may be caused by a break in the line between the dash unit and the tank unit. To remedy this, check the line and all connections. Examine the connector, which is fastened to the white wire having black crossing tracers which connects the wiring harness to the tank unit. This is located on the harness leading to the tail lamp alongside of the gasoline tank. The tank unit may be burned out. In this case, replace the tank unit. Or, the tank unit may be improperly grounded due to loose mounting screws or paint under the screw heads. Tighten the screws holding the tank unit. "Ground" the tank to the chassis and test.

If the gauge shows "empty" under all conditions, this may be caused by wires being reversed on the dash unit. To correct this trouble reattach wires to the proper terminals. If the dash unit is not "grounded," replace the dash unit.

Work in locating the trouble will be considerably simplified if an extra tank unit is available, as this can be connected up temporarily with the gauge by a short piece of wire, and grounding the body of the tank unit to the chassis. The float can then be moved to the "full" and "empty" positions. If the dash unit indicates corresponding positions, the trouble is confined to the tank unit and wiring.

FUEL SYSTEMS

THE MERCURY FUEL SYSTEM

The fuel tank which is mounted at the rear of the car is provided with a drain plug which may be removed to drain fuel or condensation from the bottom of the tank. The tank is provided with

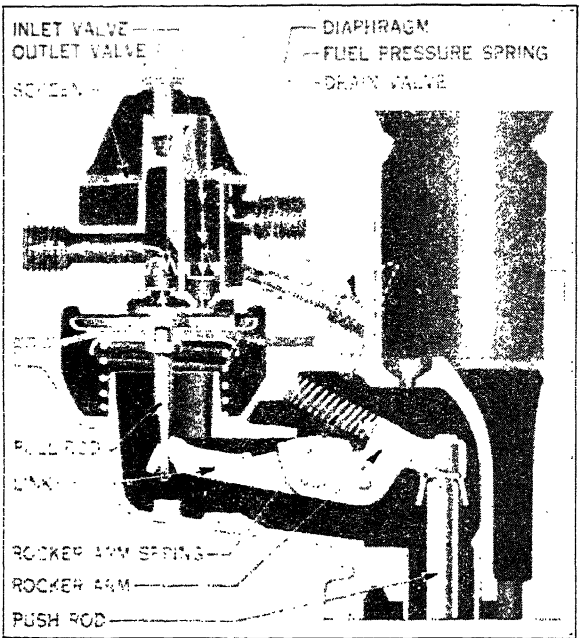


Fig. 1. Mercury Fuel Pump
Courtesy of Ford Motor Company

a trap to catch water or sediment. A simple method of cleaning the tank is the removing of the drain plug and allowing a small quantity of fuel to run out, which will carry with it any water, condensation or sediment. The electric fuel gauge is located on the instrument board. A float mechanism in the gasoline tank serves to control the electric current in such manner as to regulate the indicator on the dash. The gauge registers only when the ignition is on.

The fuel pump, Fig. 1, located on the top of the engine behind the carburetor, is operated by a push rod actuated by an eccentric on the camshaft. A sediment trap is provided in the construction of the pump. In order to drain off any sediment or water, the valve

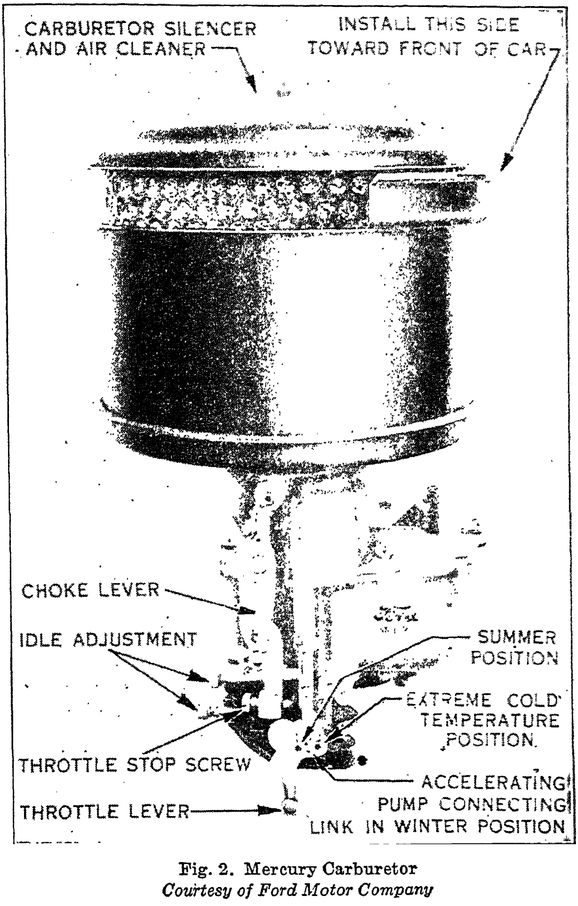


Fig. 2. Mercury Carburetor
Courtesy of Ford Motor Company

in the side of the pump should be opened. The time required to prime the pump and start gasoline flowing in case of running out of gasoline is approximately 20 seconds.

The carburetor, Fig. 2, is of the dual downdraft plain tube type with an accelerating pump and auxiliary valve choke. With the exception of the choke, which is hand controlled, the operation of

the carburetor is entirely automatic. No adjustments are provided since the orifices in the jets are all fixed, with the exception of the idling jets which are controlled by the idling adjusting screws, one for each barrel of the carburetor. The idle adjustment speeds should be set to approximately 5 miles per hour for the car. The accelerator pump should be set to No. 1 for summer position, No. 2 for winter operation, and No. 3 for extremely cold climate.

The air cleaner and carburetor silencer is attached to the carburetor on the upper end of the air intake. In order to clean the cleaner, it should be removed periodically. Remove the top cover and the filter unit. The filter unit should be washed in gasoline, after which it should be dried thoroughly and then submerged in a good grade of engine oil and allowed to drip dry before reinstalling. The felt in the top cover is not to be oiled. An oil bath air cleaner is available for Mercury cars which are to be operated in territories where considerable dust is encountered.

CARBURETORS

PART I

FUNDAMENTAL PRINCIPLES

Many mechanics, who are quite at home when repairing the purely mechanical phases of the automobile, find themselves more or less at a loss to know just how to proceed or how to interpret the instructions given when studying the action of the fuel system and particularly with reference to the action of the carburetor. The illustrated instructions that follow will serve to clear up the scientific theories involved in carburetor design and construction.

Function of Carburetor. The carburetor is a device designed to handle liquid fuel and so mix it with air, which is required to support combustion, that a highly explosive mixture is formed. The laws governing this mixture are well known. There are a number of methods by which the mixture may be attained, that is, carburetors will fall within certain definite classes which will be described later. It is sufficient at this point for the reader to know that a very definite mixture must be secured if the combustion is to be supported and the most miles per gallon secured from the gasoline used in the car.

Exact Carburetion. Exact carburetion is a scientific accomplishment. Engineers have spent a great deal of time and money to design carburetors to give the exact and proper mixtures of air and gasoline required at all engine speeds. Except for the fact that it is necessary to throttle an engine, the design of carburetors would be comparatively simple. As a matter of fact, all that would be needed would be a needle valve which could be screwed down to shut off the amount of gasoline entering with the given amount of air. This, however, would not do for more than one speed and the engine would not throttle with this sort of device, which is, in reality, a mixing valve rather than a carburetor.

Exact carburetion at all speeds is a thing which has long been the ideal sought by the engineers. Present-day carburetors are rather efficient in this respect. However, the automechanic,

without the knowledge of the underlying principles of carburetor design, is very likely to undo much of the good work of the engineer. For this reason a very definite attempt should be made to master the information as given herein.

A carburetor expert is one who not only has had considerable experience with carburetion but who also understands the fundamental principles which follow. Not only does he understand them but they are applied by him rather unconsciously, just as a good driver steers the car through traffic and manipulates his brake, clutch, and throttle almost without conscious thought.

Weight of Air. Most people do not appreciate the fact that the great sea of air in which we are living has appreciable weight. However, we are living at what might be termed the bottom of an ocean of air. As to the exact height of this ocean of air, no one can say definitely. It is variously estimated at about 200 miles in depth. Perhaps the most definite thing we know about it is that when aeroplanes reach a height of about eight miles, they hit what is termed the "ceiling," that is, the air at that point becomes so light that it is impossible to push the heavier-than-air machine higher into the atmosphere. While the air man calls this the "ceiling," it is not so in reality. No one knows definitely how much further the air goes out into limitless space.

In order to support combustion at these high altitudes, the air man usually makes use of the supercharger. This is a device, understood by most mechanics, to force in greater quantities of air in order to secure the desired oxygen and support the combustion in a better fashion. One farmer may raise fifteen bushels of wheat to one acre and another farmer raise sixty bushels to the acre. The first farmer has to gather wheat from four acres to have as much as the second farmer gets from one acre. So it is with the atmosphere at the "ceiling" a great many more cubic feet of air must be used in order to get the same amount of oxygen.

Inasmuch as we are living within this sea of air at the bottom of it, we have no sense which tells us its weight; nor are we ordinarily really conscious of it unless it becomes exceedingly dry or something of that sort. If we dip a gallon pail into a larger vessel of water, we do not appreciate the weight of the water until we attempt to lift the gallon pail, with its full measure of water, from the rest of the

body of water. Unfortunately we cannot do a similar thing with reference to the air. If we could, we would then realize the weight of it. The fact does remain that air has weight and this fixed weight or pressure, as it is ordinarily termed, has a very definite bearing on carburetor design and construction and just as much bearing on the exact setting of carburetors, which feature, of course, is the one which the automechanic is interested in. The ideal mixture of air and gasoline is one pound of gasoline to fifteen pounds of air. In order to get an idea of the amount of air contained in fifteen pounds, it would be well to study the methods of weighing air.

Suppose two vessels, constructed air-tight, each of which contain one cubic foot, are placed on the scales as indicated in Fig. 1. The vessels themselves are exactly the same weight. Now we will

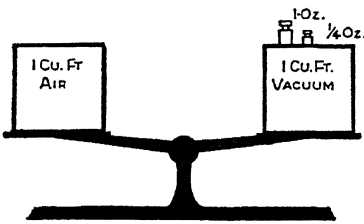


Fig. 1. One cubic foot of air is balanced by 1¼ ounces.

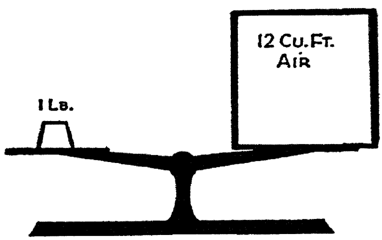


Fig. 2. One pound weight balances 12 cubic feet of air.

take one of these and attach a vacuum pump to it and exhaust all the air from the vessel and seal it. It will be found that it will be necessary to place one and one-quarter ounces of weight on the vessel, which has had the air exhausted from it, in order to balance the container on the opposite side of the scale. In other words, each cubic foot of air weighs one and one-quarter ounces. Now in order to secure 15 ounces of air it would be necessary to have twelve cubic feet. Accordingly it will be seen that 15 ounces of air, placed on the one arm of the balance, would balance twelve cubic feet of air, placed on the other one, as shown in Fig. 2. Of course the weight of the container would have to be accounted for.

Relative Weight of Gasoline and Air for Correct Mixture. It will be seen that if we were to place one cubic foot of air on one side of the balance, as shown in Fig. 1, that it would be balanced with

one and one-quarter ounces of gasoline on the other side. While the weight is exactly the same, the bulk is different. However, if we were to place one and one-quarter ounces of gasoline in a cubic foot of air, the mixture would be fifteen times too rich, so that it would be necessary to have fifteen cubic feet of air with which to mix the one and one-quarter ounces of gasoline in order to provide the best possible mixture for economical and powerful operation of the engine.

Looking at it the other way, it will be found that there are about seven and one-half teaspoonfuls of gasoline in the one and one-quarter ounces of gasoline. In other words, it takes barely one-half teaspoonful of gasoline to mix with a cubic foot of air in order to secure the proper mixture.

Bulk of Gasoline as Compared to Bulk of Air to Support Combustion. The question which arises is naturally one of how much larger the cubic foot of air is than the teaspoonful of gas. The cubic foot of air weighs just fifteen times as much, but how many times larger is it? A cubic foot of gasoline will be found to weigh almost fifty pounds. Now fifty pounds will equal 800 ounces. The cubic foot of air, with its weight of one and one-quarter ounces, would have to be multiplied by 640 to have as much weight as a cubic foot of gasoline; and it must be remembered that fifteen times as much air is required as gasoline when figured by weight. Accordingly, in order to use up a cubic foot of gasoline, fifteen times 640 is needed or 9600 cubic feet of air is used in the average gasoline engine for each cubic foot of gasoline. If it is desired to convert this into gallons, the same ratio holds. For every gallon of gasoline there must be approximately 10,000 gallons of air burned, although we are not in the habit of thinking of air being measured by the gallon. It does, however, serve as a basis of comparison. The problem then is how to mix the two in an economical fashion so as not to waste any of the gasoline.

Gasoline and Air Mixture. It will be remembered that one-half teaspoon of gas and a cubic foot of air is the proportion of about 1 to 10,000 by volume. In order to secure a good mixture of the liquid gasoline fuel, it is first necessary to have it vaporized. When a liquid is vaporized, it occupies more space; it will also float in the air. These two features are quite valuable ones and are made use of in car-

buretion. There are quite a number of ways in which the one-half teaspoonful of gasoline may be vaporized to mix with the cubic foot of air in proper fashion. If the one-half teaspoonful of gasoline were to be poured into the cubic foot of air, as indicated in Fig. 3, this would not constitute a fuel mixture, since the gasoline would simply drop to the bottom of the vessel and remain there until it was slowly vaporized by normal evaporation, which is rather slow with our present heavy grades of fuel.

Vaporization. Vaporization is evaporation. Evaporation occurs at all temperatures. Even snow and ice will evaporate, although the process is very slow. On warm days the water from the streams and lakes will evaporate very rapidly. The heat of the stove helps to boil the water and evaporates it quickly. Any liquid placed in

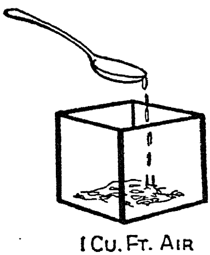


Fig. 3. Pouring a teaspoonful of gasoline into a cubic foot of air does not constitute mixing it.

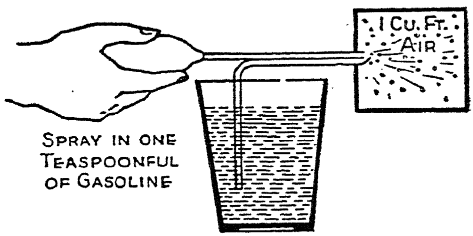


Fig. 4. Spraying a teaspoonful of gasoline into one cubic foot of air makes a combustible mixture.

contact with the air will start to evaporate and the fact that it is doing so is made noticeable by the characteristic odor of the liquid which is being evaporated. This is exactly the reason you can smell the gasoline as you approach the gasoline station. The loss to the service station from evaporation is not slight, especially in extremely warm weather or where a very high grade of gasoline is carried. As a rule the evaporated particles are not visible to the eye. In some cases we can see the fog of the evaporated fuel or liquid. It is possible to speed up vaporization by a number of methods.

The three methods of vaporization, which may be made use of by the carburetor manufacturers in designing and building the carburetor so that the gasoline and air mixture may be maintained at a 1 to 15 ratio, are atomization by spraying, vaporization by means of heat, and vaporization by production of a vacuum. These should

be held in mind constantly when studying carburetion to see just how and where each one is made use of.

Vaporization by Spraying. A vapor is a gasified liquid—in this instance the gasoline. If an atomizer were used, as shown in Fig. 4, it would be possible to spray one-half teaspoonful of gasoline into the cubic foot of air very quickly and have it fairly well mixed with the air, since it enters the air in the form of a mist. Everyone knows that some of the particles of the liquid coming from an atomizer are larger than others. These may fall to the bottom of the vessel containing the air. Naturally this vaporization is less perfect than when the particles are broken up so small and fine that they are not visible to the eye.

The use of the atomizer, as shown in Fig. 4, very simply represents one of the most important elements of design in carburetion. When the bulb is pressed, the air is forced through one tube out past a small opening in the other tube, which runs down into the gasoline container. The force of the air circulation past the small opening in the gasoline tube causes a suction which draws portions of the gasoline up through the tube. As it draws this gasoline out, the air from the bulb strikes the fuel and breaks it up into small particles or, in other words, it is atomized. Atom is a term applied to very small parts of any element and atomization means breaking into small particles. The application of this principle of atomization by spraying will be explained at a later point in this work.

Vaporization by Means of Heat. An easy way in which to vaporize a liquid is to apply heat to it. If we were to apply the heat from a Bunsen burner to one-half teaspoonful of gasoline, as shown in Fig. 5, the gasoline would very quickly be driven off in the form of a heavy vapor. The heat aids it in rising and, if the vessel containing the cubic foot of air were immediately above it, a very good mixture would be secured between the air and the vaporized gasoline. Naturally the greater the heat the more rapid the vaporization.

This principle is made use of in the carburetor by several methods. The older method was to make use of a stove, which was hooked on to the exhaust pipe at a point close to the carburetor so that the air being drawn into the carburetor was first passed around the exhaust pipe and the heat thus picked up was carried into the

carburetor to warm the carburetor parts and to assist in vaporization. In other words, the heat was carried in by the air. While stoves are still made use of for this work, later practice is the use of "hot-spots" in the manifold or special manifold tubes so that the gasoline as it is sprayed from the carburetor comes in direct contact with the heated surface. This is somewhat like dropping a drop of water on a red hot stove. It is vaporized instantly.

Vaporization by Production of Vacuum. Owing to the fact that we are living in a vast sea of air, it is rather difficult to conceive of

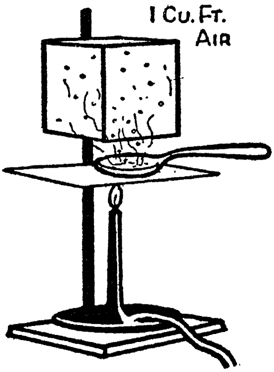


Fig. 5. Using heat to vaporize gasoline and mix it with air.

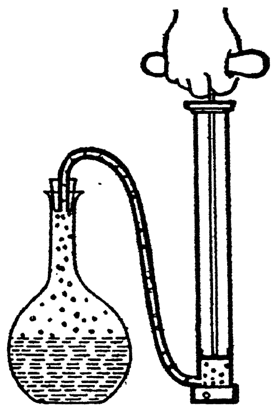


Fig. 6. The effects of vacuum on the boiling point of gasoline.

any space where there is no air. We look at a bottle and say it is empty because we can see nothing in it. We do not mean exactly what we say and we realize, of course, that it is filled with air. Being filled with air, there is a very definite air pressure of approximately fifteen pounds per inch on the inside of the bottle as well as on the outside of the bottle. If the bottle or flask is filled half full of water, as indicated in Fig. 6, and then connected up to a vacuum pump, as shown, it will be possible to exhaust the air from it with the result that, at a temperature slightly above the room temperature, the water may be made to boil without any additional heat. Ordinarily water boils at 212° F. The fact that it does not boil at a lower temperature is due solely to the pressure of the air upon the water.

If all of the pressure could be removed from the water in the flask, it would boil violently at 80° to 90° F.

This feature of the production of a vacuum over the liquid fuel has a very important place in the design of carburetors. In order to secure a vacuum into which the fuel may be discharged, a venturi tube is made use of. The venturi tube, in combination with the suction of the engine, thus provides a vacuum of fairly high order so that the gasoline, while being sprayed into the carburetor by means of the piston suction, is also vaporized, owing to the effect of the vacuum thus created.

Atmospheric Pressure. It is known that the atmosphere has weight and that the atmosphere is miles deep. The depth of the atmosphere determines to no slight extent the amount of pressure at the surface of the earth. This is illustrated by the fact that the higher we pile bricks on the hod, the heavier the hod. If the air is piled up for 100 to 200 miles, it becomes heavier and heavier. While spread out very thin or highly rarified in the upper realms nevertheless, the pressure at the earth's surface is maintained at 14.7 pounds per square inch. We are so used to this pressure, in fact our existence depends upon it continually, that we do not stop to think of this pressure or weight. The pressure is not only downward, but it is in every direction so that air is continually seeking to enter any opening or any point in which there is a tendency to create a vacuum.

Proof of Air Pressure. In order to prove that air pressure is something very definite and positive and ever-present, any one can perform this simple experiment. Secure an empty oil can of one-gallon capacity. Have a tight-fitting cork at hand but do not place it in the can. Pour a half-pint of water into the can and set the can on the stove top. Heat the can until the water within it is boiling and steam is being passed off from the top at a rapid rate. Lift the can from the stove and quickly insert the cork. Be sure to insert the cork absolutely tight. Within a very short time, the can will start to crumple and buckle. This crumpling and buckling will continue until the can looks as though it had been run over with an automobile. You have demonstrated in this simple experiment three principles or facts. One of these is that air has pressure and another is the vacuum, established by the fact that when the water was

boiling the steam came up into the can and drove almost all of the air out of the can so that nothing but steam remained within. When the can was removed from the stove, the steam condensed back to water, leaving a vacuum. This vacuum was immediately offset by the normal air pressure which, in an attempt to get into the can, forced in the sides of it, crushing it together. The third thing which was demonstrated was the fact that a small amount of liquid could be made to fill a very much larger space by evaporation, as was done when the water was boiled and it filled the entire can, driving off the air ahead of it.

The question might arise as to where there was sufficient pressure to crush the can, but it must be remembered that there was 14.7 pounds pressure on every square inch of the surface of the can. There was no pressure on the inside, since the steam was condensed back to water, because the water occupied a relatively small portion of the interior of the can. This experiment is illustrated in Fig. 7.

Vacuum. A conception difficult to establish in the mind of the average person is vacuum and just what it might be. He realizes, of course, if he stops to think about it, that vacuum is a place where there is nothing present, not even air. The question then is—what is a partial vacuum? If one-half of the air is removed from a sealed container and no more air enters, the container is still filled. The reason for this is, that air, as all gases, expands when pressure is removed from it. However, this condition would give a pressure within the container of about half of the air pressure on the outside and this is spoken of as a partial vacuum. In carburetor work a true vacuum is never secured. A partial vacuum is constantly present when the engine is running.

Measuring Vacuum. The weather man figures a great deal on the height of the mercury in the mercurial barometer. It is a well-known fact that the atmospheric pressure indicates the general weather conditions. Disturbances of the air throughout the different parts of the world are reflected in other disturbances in other parts of the earth's surface. A very slight variation in pressure is sufficient to create storms. The mercury column is the most usual method of measuring the atmospheric pressure. Atmospheric pressure is measured at sea level.

Many years ago it was discovered that it was possible to pump water from a well by means of a suction pump, as long as the well did not exceed approximately 34 feet in depth. The pump is used to create a vacuum and the normal air pressure on the upper surface

Fig. 8. Comparing the weight of pressure downward of Air, Water, and Mercury. Columns of the height shown, each have a downward and outward pressure of 14.7 pounds for each square inch.

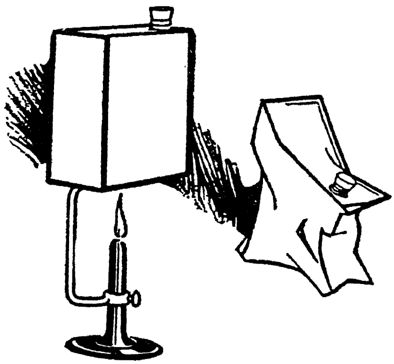


Fig. 7. Positive proof of the weight or pressure of air.

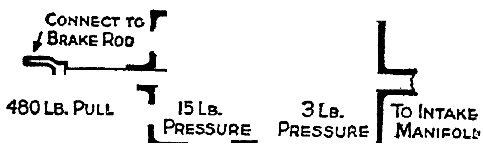


Fig. 9. Showing how the vacuum created by the engine may be utilized for work

of the water forces it to flow up into the pump stock after the air, which has been removed above it. In other words, a normal air pressure will lift water to a height of 34 feet if all pressure has been removed from the tube in which the water is to rise.

The heaviest fluid known to science is mercury. It is found that a column of mercury 30 inches high weighs just as much per square inch as a column of water 34 feet high. Either a column of water 34 feet high or a column of mercury 30 inches high just balances a column of air over a hundred miles high, according to scientists. The rough comparison of these figures is shown in Fig. 8.

As an experiment, take a glass tube 32 inches or more in length and fill it with mercury. Have a small vessel of mercury at hand and insert the lower end of this tube into the vessel of mercury, while keeping one finger pressed tight over the upper end of the tube. Note the height at which the mercury stands, measuring it from the top of the surface of the mercury in the open vessel to the point at which the mercury stands in the tube. The device you have constructed is a barometer and it measures carefully the air pressure at which the experiment is performed, ordinarily it will be around 29 to 30 inches in height. At sea level, it should be approximately 30 inches. However, it will be found that there is a portion of the tube in which there is no mercury. In this portion of the tube there is a perfect vacuum, because there was no air in the tube to start with. If the finger is lifted from the tube, it will be found that the mercury immediately runs into the vessel below. What is it that holds the mercury up into the tube?

Putting the Force of Vacuum to Work. The ability of vacuum to do work is not generally appreciated, although there are a number of devices on the market which make use of the vacuum created by the engine in its normal intake of fuel and air operation. One of the most common uses to which the vacuum has been placed is the drawing of the fuel supply for the engine by means of the vacuum tank. The vacuum tank is nothing more than a device so arranged that air may be drawn from the inside of it and a valve opened to the main supply tank at the rear of the car, so that air, in trying to enter the vacuum tank, forces the fuel ahead of it through the fuel supply line to the vacuum tank.

A device which illustrates the work which may be done by vacuum is shown in Fig. 9. This is a cross section of a vacuum brake. It consists of a cylinder with a cup washer piston on the end of a pull or piston rod. A tube connects one end of this cylinder to the intake manifold of the engine at a point just above the carburetor,

which is the greatest point of vacuum. Now, as the engine is running, the air is drawn from the sealed cylinder until it has about 3 pounds pressure left—that is, in a good engine a vacuum of about 12 pounds or 22 to 24 inches on the mercury may be secured. The normal air pressure on the opposite side of this cup washer piston is approximately 15 pounds, so it will be seen that for every 3 pounds of pressure within the sealed end there are approximately 15 pounds on the other side of the washer, forcing the piston into the cylinder. A 7-inch cylinder of this general design will develop approximately 450 pounds pressure or pull, which may be applied to the brake rod. This is exactly the same principle made use of whenever the vacuum is used for any work. There are other devices which are occasionally attached to the engine intake manifold.

The force of vacuum is depended upon to develop the suction for the spraying or atomization elements of carburetor design. A vacuum which is created just above the venturi, in what is known as the mixing chamber of the carburetor, is the point at which the major portions of the combining of the air and fuel mixture occurs.

NORMAL ATMOSPHERIC PRESSURE REGULATES CARBURETOR DESIGN

The normal air pressure is approximately fifteen pounds per inch. It is always present and immediately seeks a way into any space which is vacated by another element or from which other air has been drawn. Vacuums may be complete, but as a rule are only partial. This is especially true with reference to the carburetor. A series of illustrations have been especially prepared to show the action of the carburetor as the pistons within the cylinder draw or suck air and fuel through the carburetor.

Referring to Fig. 10, it will be noticed that a piston has been provided in a cylinder and a cross tube is open to the air. Now, as the piston is pulled downward, it is readily seen that the air will follow in through the tube. Since there is no restraint to the amount of air which may enter, normal air pressure is found throughout the tube and cylinder.

In Fig. 11, the same tube is shown with the addition of a bowl of gasoline connected to the cross tube by means of a smaller tube. It will also be noted in this figure that the end of the cross tube has

been closed. Now when the piston is started traveling downward, the air which is in the cross tube and upper part of the cylinder will become thinned out or a partial vacuum will be created. This results in suction on the gasoline bowl and in gasoline being forced into the cross tube where it mingles with the air which was already in the tube. As the piston travels downward, the vacuum becomes more and more complete and a richer and richer fuel flow will occur.

In Fig. 10 we have shown how air may be drawn in, and in Fig. 11 we have shown how gasoline may be drawn in by the piston action or suction. In Fig. 12 the end of the cross tube has been opened again, otherwise the arrangement is similar to that in Fig. 11. It will be noted that both air and gasoline will be drawn as the

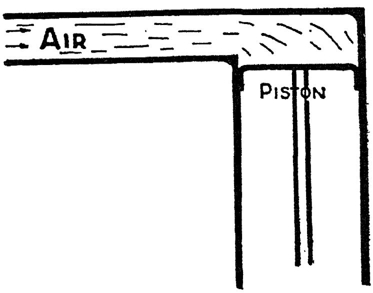


Fig. 10. Action of a simple piston in a cylinder in creating suction. (Valves omitted.)

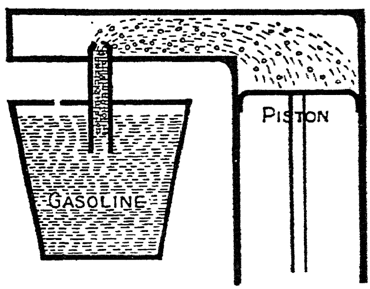


Fig. 11. Showing how the piston will draw in raw gasoline if no air vent is provided.

suction of the piston acts upon the device. There is a constant flow of air mixed in with the rather constant flow of gasoline. The mixture consequently does not become so rich as that shown in Fig. 11. As the amount of gasoline is very small in proportion to the amount of air, the gasoline tube is relatively much smaller than the air opening. This holds in all carburetor design. The speed with which the piston travels regulates the degree of vacuum. The faster it travels, the greater the suction and the more rapid the action of the fuel flow as well as the air flow.

Regulating Flow of Air and Gasoline. From the rather simple starting point just described and considering the same principles, the following illustrations will serve to show how engineers make use of mechanical devices and scientific principles to control and regulate the flow of air and gasoline so as to secure a proper gasoline mixture.

A comparatively simple device, such as that shown in Fig. 12, could be designed with fixed air and gasoline openings so that it would serve very well to operate an engine at a fixed speed. It would not be possible to throttle the engine, neither would it compensate for varying loads. In Fig. 13, a gasoline needle has been added. This is so arranged as to control the amount of gasoline which will flow through the gasoline tube to mix with the incoming air. The wider the needle is open the more gasoline; and the further into its seat it is screwed, the less gasoline flows through the tube. By the use of such a device, it is possible to adjust this simple carburetor for varying loads and varying speeds of any one engine; but

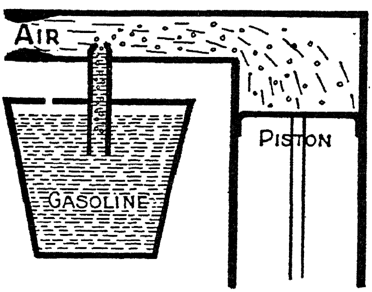


Fig. 12. Showing a simple carburetor—a gasoline tube in an air tube supplied from a vessel of gasoline.

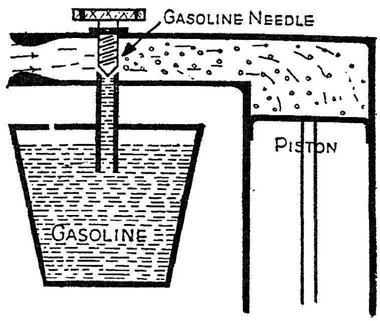


Fig. 13. Simple Gasoline Needle Adjustment.

it still does not lend itself to throttling, as is necessary with the automobile.

It must be remembered that in all cases, with all carburetors, it is necessary to have the gasoline and air mixture at approximately 1 to 15. This is irrespective of the speed of the engine or the load of it. For this reason it will be seen that the design of the carburetor becomes more and more complex.

There is another method of controlling the proportions of air and gasoline. This is what is known as the auxiliary air opening and is shown in Fig. 14. It will be noted that the cross tube has been provided with two air openings—the original one at the end and another one at the top. The air entering at the top mingles with the air which has entered at the end of the tube and picked

up the gasoline, so that the mixture is leaned out. Here again we have a device which could be designed for any fixed engine speed and fixed engine load, but it does not lend itself to throttling nor does it automatically compensate for variation in speed or in load.

Automatic Control of Air and Fuel Mixture. As has been stated, it is necessary to have a device which will automatically control and hold the air and fuel mixture within the limits of approximately 15 to 1, irrespective of engine speed or engine load.

Auxiliary Air Valves. Some of the first attempts to design carburetors led to the discovery of the auxiliary air valve as a practical unit for automatic control of the fuel mixture and holding it within the prescribed limits of 1 to 15. The application of a valve of this type to the auxiliary air intake opening is illustrated in Fig. 15. When the engine is running, the piston, on the down stroke, draws air in through the end of the cross tube which picks up the gasoline as it passes the gasoline nozzle or tube. This rich mixture then passes the auxiliary air valve and enters the cylinder. As the speed of the engine increases, the amount of air coming in is increased along with the suction and this increased suction will open the auxiliary air valve a distance, depending upon the amount of vacuum or suction, so that in an automatic way the suction itself increases the auxiliary air valve opening and allows an increasingly large amount of auxiliary air to enter and lean out the mixture which otherwise would grow too rich.

A simple carburetor, such as shown in Fig. 12, can only be designed for one fixed engine speed and fixed engine load. When an attempt is made to increase the engine speed beyond this point, it is found that the increased suction increases the richness of the mixture out of all proportion to the demands of the engine. This is due to an inherent law controlling the flow of air and liquids. It is for this reason that we must have some automatic means of controlling the mixture, such as the air valve, Fig. 15. Then when the mixture grows too rich, the auxiliary air will enter to thin it out and thus automatically the proper proportion of 1 to 15 will be maintained.

Metering Pins. While the theory of the auxiliary air valve is a truly scientific one, it does not serve to make the carburetor entirely automatic over the wide range of speeds and loads which the auto-

mobile engine must handle. It is found desirable to hook up what is known as a metering pin, with a throttling action, in many carburetor designs. Sometimes this metering pin action is in connection with the auxiliary air valve, so that both air and gasoline are controlled automatically by the suction which opens the air valve. A device such as this is illustrated in Fig. 16, where it will be seen that the air valve is connected by a short lever to the metering pin, taking the place of the needle valve which was introduced in the simple carburetor arrangement in Fig. 13. The needle in Fig. 13 was manually adjusted by screwing it in or out. The metering pin or needle in Fig. 16 is automatically adjusted by the suction of the engine, which acts on the air valve. When the piston speed, in the

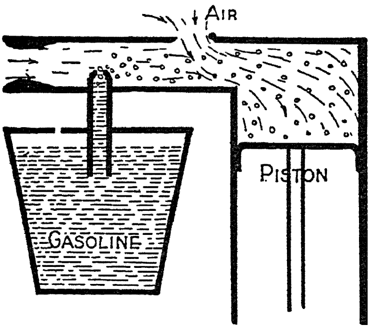


Fig. 14. Additional Air Supply to Prevent too Rich Mixture

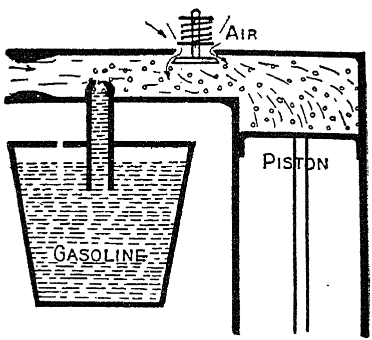


Fig. 15. Automatic Air Valve

device shown in Fig. 16, increases beyond a certain point, the air valve is drawn down. As it is drawn down, the lever pulls the metering pin up. As the metering pin rises, the amount of gasoline passing upward through the gasoline tube is measured in a rather accurate fashion. The farther the metering pin is raised, the larger the amount of gasoline which may flow past it into the cross tube.

It will be seen that by carefully figuring the spring pressure on the air valve and just as carefully and scientifically figuring the size of the metering pin with reference to the gasoline tube and especially by giving attention to the taper of the metering pin, that almost any desired amount of gasoline may be fed into the air stream, depending upon the demands of the engine. It will further be seen that when the exact point at which the air valve will open is reached under certain engine speeds, that the amount of air entering can be

figured exactly and then the form of metering pin of the desired characteristics may be used to admit just the right amount of liquid, fuel, or gasoline.

These simple hook-ups shown in Fig. 16 represent the fundamental principles made use of by many carburetor designers and manufacturers. As a general rule, the mechanism is far more complicated than that illustrated, but the principle involved is the same; the idea being that a fuel and air mixture ratio of 1 to 15 must be maintained.

Dashpots. Owing to the peculiar nature of air with respect to its lightness and elasticity, an arrangement or air valve similar to that shown in Fig. 15 is likely to be more or less erratic, that is, the

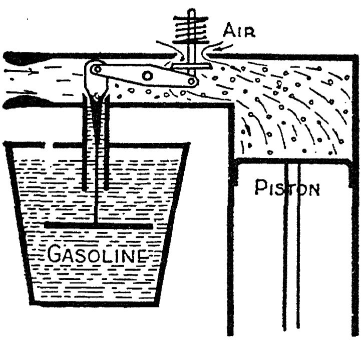


Fig. 16. Automatic Air Valve with Metering Pin and Dasher Attached

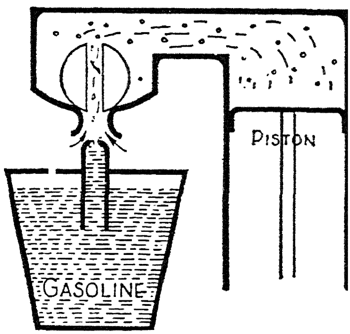


Fig. 17. Ball Used for Air Valve

air valve will flutter in and out as the pistons deliver their suction impulses to it. In order to control this tendency to flutter, a dasher is attached to the air-valve mechanism. As a rule, it is somewhat similar to the form shown in Fig. 16, where a metal plate or disc has been fastened to the end of the metering pin. It will be seen that when the air valve tends to flutter, this plate must be moved up and down in the liquid gasoline, which is in the bowl of the carburetor. Any one knows that fluid resists rapid movement of anything through it. This device effectually overcomes the tendency of the air valve to flutter and thus cause an uneven mixture and unevenly operating engine. This is a very elementary design and in actual practice, when looking over carburetors for dashpots and dashers, they will be found in a variety of forms. Generally the

action of the dashpot is further regulated by the use of small ball check valves.

Pneumatic Control of Air and Fuel Mixture. The sole purpose of a carburetor is to provide a mixture of one pound of fuel or gasoline to fifteen pounds of air, so that the engine may operate evenly under all conditions. It was early learned that the pneumatic principle, that is, gravity in connection with air flow, could be made use of in order to control the fuel mixture within the desired limits. Fig. 17 shows a simple form of carburetor which is somewhat different from the one shown in Fig. 12. It will be noted that the gasoline tube is not connected directly to the cross tube of the device. Instead a small opening has been provided in a recess of the tube, at

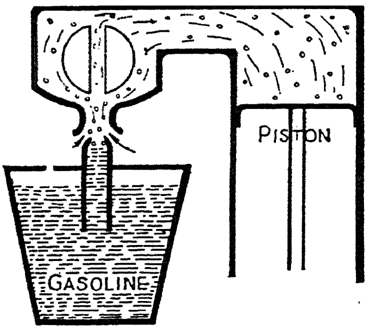


Fig. 18. Suction Lifting Ball in Pneumatic-Principle Carburetor

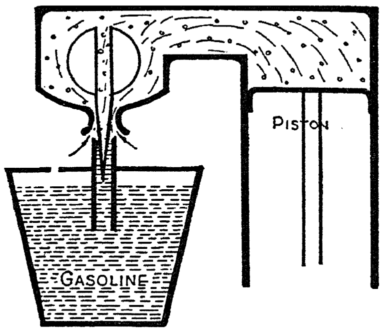


Fig. 19. Metering Pin Attached to Ball Valve

the bottom. This opening is in the nature of a small venturi. From this opening or venturi, resting on its upper surface, is a ball. This ball has a hole drilled through it. When used as a simple carburetor, it will be found that the engine speed will be steady up to a certain point, when the suction increases and lifts the ball from its seat as shown in Fig. 18. When the ball is lifted from its seat, an additional amount of air is allowed to enter the carburetor. It will be noted that this action is very similar to that of the auxiliary air valve and serves the same purpose of controlling the mixture within the desired ratio. It will be well to make a study of the interesting arrangement of the gasoline tube shown in Figs. 17, 18, and 19, which sets within the bottom of the venturi or opening into the cross tube of the device. It will be noted that the air, in entering the tube, must pass the upper edge of the gasoline tube. As it passes this

point, it creates the desired suction which draws and lifts the gasoline into the cross tube and on down into the cylinder. It will be seen that the general shape of this opening into the cross tube has much to do with the amount of gasoline which will be drawn from the gasoline tube. This is the device which is used in practically all carburetors, in some fashion or other. It is called a venturi and the gasoline tube is called a gasoline nozzle. The upper end of the gasoline nozzle is always within the lower end of the venturi.

In scientifically-designed carburetors of this type a metering pin is always used in conjunction with the ball, which is always lifted from its seat by the suction of the piston. This is illustrated in Fig. 19, where the metering pin is shown attached to the ball

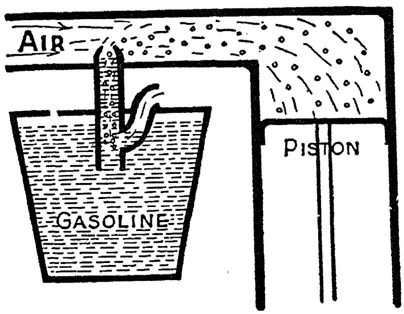


Fig. 20. Air-Bled Gasoline nozzle

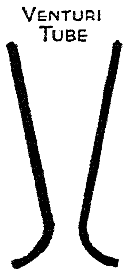


Fig. 21. Venturi Tube
Used to correct flow of air and give a partial vacuum for better vaporization.

valve. Now it will be noted that as the suction increases and the ball is lifted farther and farther from its seat, more gasoline is allowed to flow from the gasoline tube; so again we have a means of scientifically and exactly regulating the amount of fuel which will enter a given amount of air so that we can maintain the 1 to 15 ratio. This action is entirely automatic, depending altogether upon the speed of the piston and the suction developed by this speed.

Air-Bleed. Referring to the simple carburetor shown in Fig. 12 and then to the modified form shown in Fig. 20, it will be noted that a new method of controlling the amount of gasoline flowing through the gasoline tube has been introduced. This is in the form of an air opening into the gasoline tube so that as gasoline is drawn from the carburetor bowl and mixed with the air passing it, auxiliary air is drawn into the gasoline, passing from the carburetor through

the gasoline tube to the cylinder. This is what is termed an air-bleed jet. Instead of a solid stream of gasoline being drawn into the cross tube to mix with the air, air bubbles are drawn with the gasoline from the gasoline tube. These air bubbles serve to break up the gasoline into smaller particles so that the further action of the air upon them results in better atomization and a better fuel mixture.

There are a number of carburetors on the market which make use of this principle. Very definite scientific laws are known with reference to the flow of both liquid and air. By controlling the openings for air and fuel or by controlling what is known as the size of the tubes used in these carburetors, it is possible to have carburetors designed and manufactured which maintain the ratio of 1 to 15 without the use of any mechanical means, such as the metering pin or the auxiliary air valve.

Venturi Tube. It has long since been learned that air may be passed through a tube, the form of a venturi tube, shown in Fig. 21, with great ease and when so passed will develop certain desired results. The problem in carburetor design is to secure the proper suction from the gasoline needle at slow speeds and then at the same time to permit enough air to enter at high speeds so that the desired ratio of air and fuel may be maintained. The venturi tube lends itself to this combination of several extremes. Fig. 21 shows a cross section of such a tube and it will be found in all cross sections of carburetors shown in this book. Fig. 22 shows a simple carburetor which makes use of the principle of the venturi tube. The nozzle in this case is located in the venturi tube, much after the fashion of all venturi tube and gasoline tube construction. It will be noted that as the piston descends into the cylinder and suction is set up around the nozzle where it is placed in the lower part of the venturi, air enters the venturi and picks up the gasoline as it passes.

Vacuum has a very decided effect upon vaporization. Due to the peculiarity of the construction of the venturi tube, it tends to produce a partial vacuum in its upper end when air is drawn through it. It will be noted, of course, that the lower part of the venturi tube is constricted and the upper part is opened wide. Air, passing through at a fixed speed, is more or less confined at the small part of the venturi and then expands to fill the upper end of the venturi,

with the result that a partial vacuum is secured. Owing to the suction of the piston and the restriction of the flow of air at the smaller part of the venturi, all carburetors are provided with what is termed a mixing chamber. This mixing chamber is always located above the gasoline nozzle and close to the upper part of the venturi. A partial vacuum exists in the mixing chamber and just as water may be boiled more readily in a vacuum than it may be under normal air pressure, so the gasoline tends to vaporize more readily in this partial vacuum.

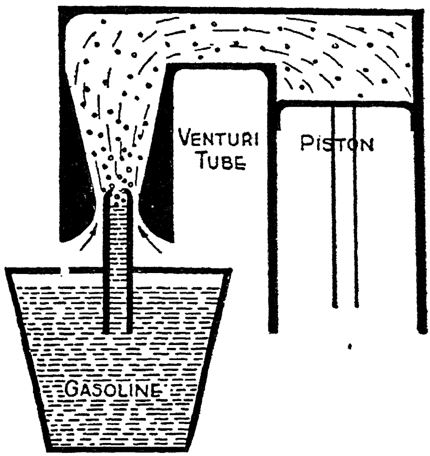


Fig. 22. Cross section of Venturi Tube with Gasoline Nozzle as Used in Carburetor Design

Heat. As was explained and illustrated in Fig. 5, it is easier to vaporize fuel by adding heat to it. In the average carburetor, heat is picked up by the air as it enters or it is supplied by providing a combination exhaust and intake manifold which results in what is termed a "hot spot." The hot spot is nothing more than a thin metal wall between the exhaust and intake manifolds. When the globules of gasoline or fuel strike this hot spot, they are steamed and vaporized. The use of the combination manifold is meeting with more favor with carburetor manufacturers than the use of the hot-air stove, which at one time was considered the best means of heating the mixture. The change is the result of the different methods used in refining gasoline. In other words, gasolines used today are

not so volatile (easily vaporized) as they were formerly. The hot spot, which becomes heated to a very high temperature, acts in a better fashion than the heat picked up by the air as it would pass through a hot stove on the way to the carburetor.

Another objection to the use of the hot stove is the fact that air, once it has been heated, expands very rapidly and less expansion is left to the air after it enters the carburetor and the full effect of the vacuum is not secured in the mixing chamber. Frank Lockhart made a very real contribution to carburetor design when he discovered that air expanded so rapidly from heat on his racing cars that it was necessary to re-cool the charge before it entered the cylinders.

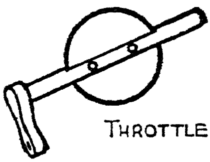


Fig. 23. Throttle Valve with Control Attached

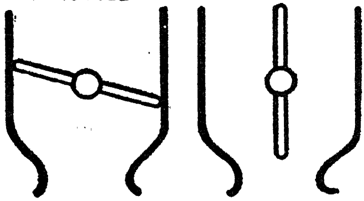


Fig. 24. Open and Closed Throttle as Illustrated in Conventional Drawings

Throttling the Car. The butterfly throttle is used in all carburetors for controlling car speed. This is a relatively simple device and is illustrated in Fig. 23. When the foot accelerator is depressed, the throttle is first cracked or opened very slightly and then gradually opened to its full open position. Closed and open positions for the throttle are illustrated in Fig. 24. When starting an engine, it is desirable to have the throttle closed or almost closed. The reason for this is that the engine is turning very slowly and no considerable vacuum is secured if the throttle is opened any great amount. In other words, vacuum is desired and necessary if gasoline is to be raised from the carburetor bowl to the mixing chamber and then carried through the intake manifold to the engine. The distance it is lifted will vary in different cars, but it will fall within the limits of 4 to 10 inches usually. Very often carburetors are provided with a special starting jet, which is placed just above the edge of the

throttle valve, as shown in later figures. This jet passes a sufficient amount of gasoline to provide for starting but immediately the throttle valve is opened, the suction on this jet drops to such an extent that it shortly ceases to function and no more gasoline is drawn through it. This feature, which is used to secure easy starting, is incorporated in a number of carburetors.

Not infrequently certain mechanical arrangements are provided in connection with the action of the throttle or butterfly valve. Sometimes the arrangements are hooked on to the control rod on the outside of the carburetor and at other times they are hooked on to the butterfly valve which is always within the mixing chamber. When these devices are hooked on the opening of the throttle, certain levers which control air valves, metering pins, and dashpots are set into motion in such fashion that the desired mixture of 1 to 15 is secured in a rather mechanical fashion. Naturally mechanical designs of this nature are worked out in a very exact way. Wear, which is the result of vibration and use, may put these mechanical devices out of balance with the result that a carburetor cannot be adjusted to perform properly. This is particularly true with carburetors on cars which have seen many miles of service. The method of repair, of course, is obvious. The worn parts must be replaced and the new ones properly set and adjusted.

Carburetor Floats and Bowls. Although there is a tendency to get away from the carburetor float, they are used in most instances. The purpose of the bowl is to provide a reservoir of fuel from which the supply used by the engine may be drawn. The purpose of the float is to regulate the level of the fuel within the bowl. While on the face of it the float and bowl are relatively simple, they play a very important part in the actual ratio of fuel mixture. The level of the fuel within the bowl has been calculated in a very exact way. The float needle and float have been designed to maintain this level, which is usually just a little bit below the upper end of the gasoline needle where it is placed in the lower end of the venturi. Naturally the nearer the level may be to the top of this tube, the easier it will be to draw gasoline from the reservoir or carburetor bowl. It will therefore be seen that if the setting of the carburetor float and needle valve are changed by accident or any other reason, "spitting" of the carburetor may result on the one hand and on the other hand

the level may be so low within the carburetor bowl that it is practically impossible to start the engine or to adjust the carburetor to secure a smooth running engine. Most carburetor manufacturers give specifications for the upper level of the gasoline within the bowl in relation to the upper end of the gasoline needle.

Fig. 25 shows the principle of the carburetor bowl and float. Gasoline entering from the feed line passes the needle valve and, as the gasoline fills the bowl, the float rises on the gasoline and by means of the level so forces the needle valve down into the valve seat on the end of the gasoline feed line, thus shutting off the flow of gasoline until such time as the engine has drawn some gasoline from the carburetor bowl and more gasoline is needed.

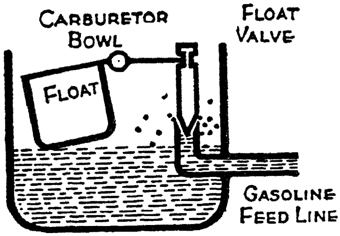


Fig. 25. Principle of Carburetor Float and Bowl

Needle Valves. Needle valves—or spray nozzles as they are sometimes called because of the function they perform—constitute an important part of every carburetor or liquid-vaporizing device. It might be thought that so long as there is a hole by which the fuel can enter the vaporizing chamber that is sufficient; yet such is far from the case. In addition to the function of an entering hole, the needle has the additional duty of breaking the fuel up into a fine spray or mist, the particles of which are easily picked up by the inrushing air and as easily converted into a vapor. Therefore, that shape, form, or arrangement which will divide the entering liquid up into the finest particles will be the most efficient. The difference of opinion on this latter point has produced the large number of shapes of nozzle and needle which are now in use. In general, practically all these can be divided into four groups, illustrated in Fig. 26.

The simple vertical tube at *A* is a round vertical tube with an opening in the top through which the liquid may pass out. It does not alter the type if the sides of the opening converge, diverge, or are straight, but it will influence the resulting spray somewhat.

Type *B*, Fig. 26, is similar to the first, except that an adjustable pointed needle is added on the inside. This occupies most of the center space, forcing the liquid to pass out in a smaller circular sheet or stream than would be the case with Type *A*, considering equal-sized holes. In addition, the fact that the internal needle valve may be raised or lowered allows this stream to vary greatly, both as to quantity of fuel flowing and the extent to which it is spread out. When the needle is down very low, only its point enters the hole, so that practically the full area of the latter is available, the central needle influencing the column of fuel passing out only to make it hollow in the center.

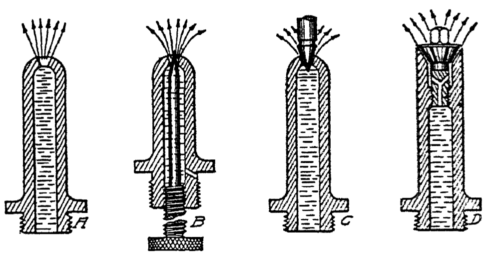


Fig. 26. The Four Usual Shapes of Gasoline Needle Valves and Spray Nozzles

With the needle raised to nearly its maximum height, however, the point projects clear through, and the needle shaft almost fills the lower part of the hole This reduces the flow to a very fine hollow column of spray, as the shape of the needle and of the lower edge of the hole is such as to force it inward and then outward so that as it leaves the top of the hole it is diverging widely. Thus the effect of the addition of the needle is to allow the use of much smaller quantities of liquid with the same-sized hole, of diffusing it more widely, and of making it adjustable to varying needs. Despite all its advantages, only three of the carburetors and vaporizers shown use this type; and of these, one is a combination of this with *A*.

The third type shown at *C*, Fig. 26, is an inversion of *B* in that the needle is made external and descends from above into the hole

in the nozzle. In this form, the shape of the needle point produces the desired diffusion and spraying effect, which accounts for its position.

The fourth form, shown at *D*, is like *C* except that instead of a needle resting upon the upper surface of the hole and allowing a continuous hollow stream of fuel to flow, a series of holes break up the column into a number of very much smaller columns, each with its own opening. In this form the central member may be movable or not, while the holes may be set at any angle. Of the examples of this form, every one has the holes placed horizontally instead of inclined to a vertical, as shown in Fig. 26. Of these, two show a combination of *B* and *D*, which is an effective combination.

ZENITH CARBURETORS

Underlying Principles. Zenith carburetors are designed to operate on the "balanced ration" principle. It means that no matter what the speed of the engine, there is a fixed ratio of air and fuel available for consumption within the combustion space. While the suction of the engine and the vacuum thus created varies with the speed of the engine and while the fuel required varies with the speed, the proportion of gasoline to the cubic foot of air must not vary if the carburetor is to perform properly and carry the load at varying speeds.

The Zenith method of securing the balanced ration, or fifteen pounds of air to one pound of gasoline, with the widely varying engine speeds and conditions of vacuum, is what is known to scientists as the Bavery principle. It is named for the French scientist, M. Bavery, who invented the Zenith carburetor.

Natural laws are made use of in this plain tube carburetor. There are no moving parts such as air valves, levers, etc. In Fig. 27 a small venturi has been provided at the opening of the air tube so when the piston travels downward, air is drawn through the venturi, past the gasoline nozzle, from which gasoline is drawn. Both the venturi and the gasoline tube have fixed openings. This is the condition mentioned as providing an increasingly rich mixture. It would be satisfactory for a fixed engine speed with fixed loads, but as the engine picks up speed the mixture grows too rich.

A method of doing away with this type of tube and supplementing another is illustrated in Fig. 28. Instead of a tube at the top of the gasoline bowl, a fixed opening has been provided at the bottom of the gasoline bowl. The gasoline flow from this fixed opening drops into the bottom of a well, from which point it is picked up by the suction of the engine and carried up through the plain tube. It will be seen that this well is provided with an opening at the top. No more gasoline can be drawn from the well than flows through the fixed opening into it. Air will be drawn through the plain tube along with the gasoline.

It will be readily understood that a device of this kind could be arranged to operate an engine at, say 500 r.p.m.; but if the speed

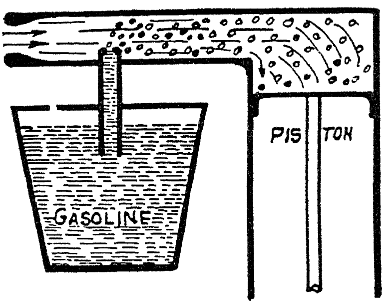


Fig. 27. The piston descending in the cylinder draws liquid fuel from the plain nozzle.

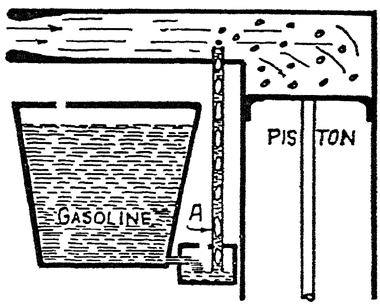


Fig. 28. The piston descending in the cylinder draws air and liquid fuel from the tube *A*.

of the engine were increased to 1000 r.p.m., there would be a decided shortage of gasoline since the mixture would grow leaner and leaner as the engine speed increased. The reason for this is that there is no suction whatever upon the amount of gasoline flowing from the gasoline bowl. This, it will be seen, is just exactly opposite that illustrated in Fig. 27, where the mixture grew richer and richer.

In order to provide a carburetor which is entirely automatic in operation, these two principles illustrated in Figs. 27 and 28 were combined in Fig. 29. Air enters through the small venturi as the engine picks up speed. The mixture coming from the plain tube at the top of the gasoline bowl becomes richer and richer. Suction is also drawing gasoline up from the well through the tube *A*. This mixture grows leaner and leaner. As these two mixtures are mixed

together, a very satisfactory mixture is secured for all engine speeds. In other words, the enriching features of the first plain tube arrangement are offset by the leaning of the second plain tube arrangement so that they compensate for each other and the engine may be operated at any speed whatever with a very satisfactory fuel mixture. Naturally the calibration of the openings must be very accurate, considering the size of the engine to be handled. For this reason carburetors are not interchangeable over a wide range of engines. A carburetor is designed for some specific engine and performs with greatest satisfaction on that one engine. If it is changed to another engine, then the nozzles which control the openings in the fixed

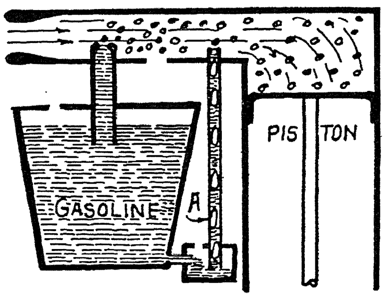


Fig. 29. The piston creates suction which acts on both tubes or nozzles and the mixtures unite with each other.

tubes must be changed and not infrequently the venturi or the carburetor throat must also be changed.

Zenith Design. Fig. 30, while being similar to Fig. 27, shows a section more nearly that of the standard carburetor. It shows the throttle, mixing chamber, the plain gasoline nozzle in the venturi, the gasoline bowl with a float control, and other features of carburetor construction. The throttle in this case is set at a wide-open position. It will be noted that a very great amount of gasoline has been drawn out and, as in Fig. 27, the tendency is for the mixture to become too rich. Note the globules of gasoline above the gasoline jet *G* in the venturi *X*.

In Fig. 31 the opposite arrangement is shown. It compares with that in Fig. 28. A calibrated opening shown at *I* allows the

gasoline to drop into the well *J*. The well *J* is open to the air and as the suction of the engine increases, owing to increased speed, the mixture shown flowing from the nozzle *H* becomes more and more lean and it is mixed with the air in the venturi *X*. Again the throttle is shown in wide-open position. Neither the arrangement shown in Fig. 30 nor that shown in Fig. 31 will give a balanced ration.

In order to secure this balanced ration, it is necessary to combine the arrangement shown in Figs. 30 and 31, as shown in Fig. 32. Gasoline enters the bowl *F* and flows through the tube and nozzle *G* into the bottom of the venturi *X*. A certain amount of gasoline

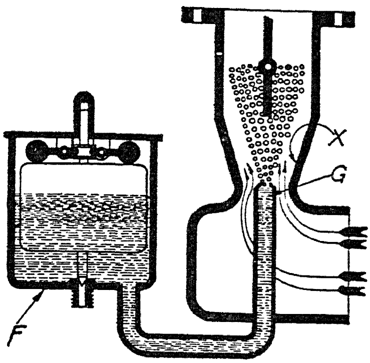


Fig. 30. Section of simple carburetor with one plain tube. The mixture grows too rich.

flows through the fixed opening *I* into the bottom of the well *J* and rises into the tube *H*, which is around the tube *G*. Now it will be seen that as the engine is throttled and the speed increases, the center nozzle gives a mixture that is too rich and the outer nozzle gives a mixture which is too lean. The gasoline and air mingle in the mixing chamber *X* and an ideal mixture is secured for operating the engine at all speeds.

The Zenith 150 Series Carburetors, Fig. 33, are used on passenger car, truck, bus, taxicab, industrial and farm equipment, wheel tractors, and marine engines.

Carburetor Operation. The Zenith compound nozzle system of carburetion is used in all models. This consists of two jets—the main jet, directly connecting the fuel in the bowl with the air stream

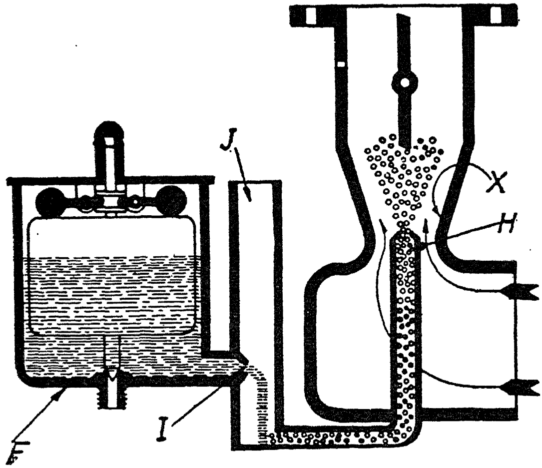


Fig. 31. Section of a simple carburetor, with a plain tube set into a well, fed by a calibrated opening. The well *J* is open to the air. Mixture grows too lean.

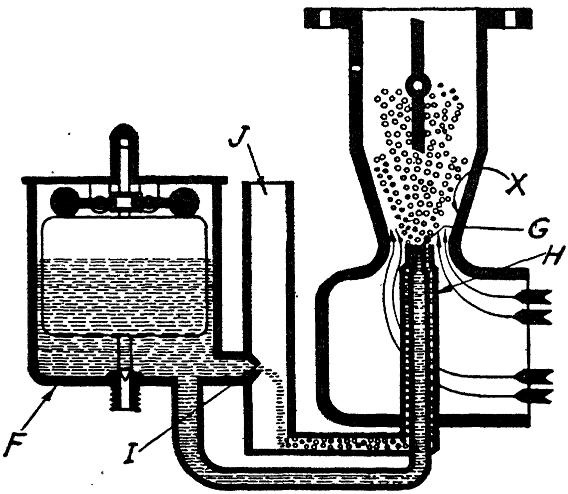


Fig. 32. The two plain tubes are combined in one compound nozzle. The nozzles supplement each other to give a proper mixture at all engine speeds without resort to moving parts.

in the carburetor barrel through the main jet discharge tube, Fig. 34, and the compensating jet flowing into an open well and connected with the air stream through the supplemental jet.

The main jet flow varies with suction, delivering more fuel as the engine speed increases, thus its tendency is to richness at top engine speed. The compensating jet is not affected by suction, therefore, it flows the same at all speeds and has a tendency to leanness at top engine speed. In combination, the rich and lean jets give an average mixture of correct proportion.

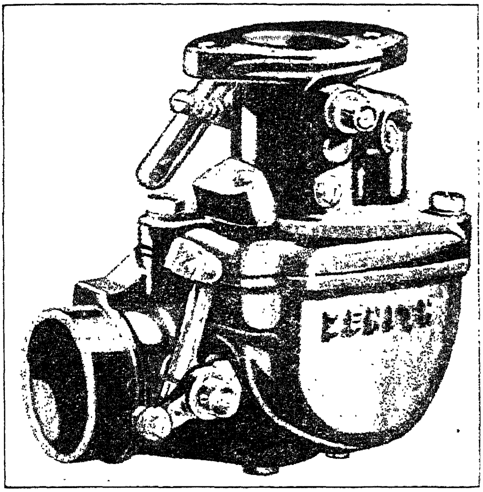


Fig. 33. Zenith 150 Series Up-Draft Carburetor
Courtesy Zenith-Detroit Corporation

Idling. The idling system functions only on starting and idling. When the throttle is opened past the idling position, the fuel goes the other way through the discharge tubes and the idling system is automatically out of operation. It consists of an idling jet and tube to supply the fuel, an idling needle valve to correct the idling mixture, and a channel to carry the mixture into the carburetor barrel at the edge of the throttle. The desired idling speed is set by the stop screw on the throttle lever.

Full Power and Acceleration. Full power, either for top speed or hard pulling, requires a richer mixture than part throttle operation. So does acceleration. This additional richness of mixture is provided

by combined accelerating and economizing systems operated by the vacuum above the throttle valve. There is a plunger pump to force fuel into the air stream, a check-valve to prevent fuel from being forced back into the fuel bowl, and an economizer valve to control the additional fuel flow. The suction above the throttle holds the pump at the top of the pump well when the throttle is partially closed. As the throttle is opened the suction decreases, releasing

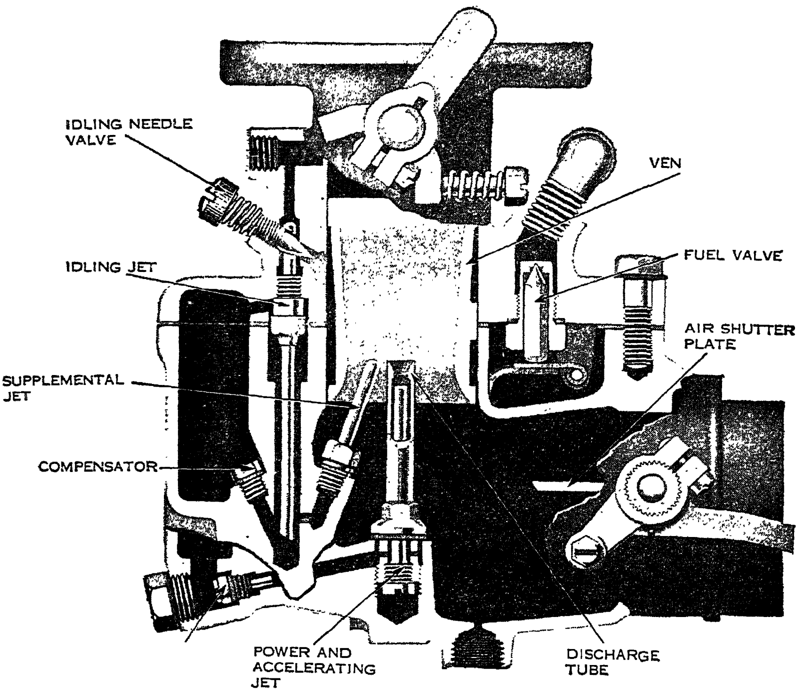


Fig. 34. Sectioned View Zenith Series 150 Carburetor
Courtesy Zenith-Detroit Corporation

the pump which drops to the bottom of the well, forcing fuel ahead of it. The economizer valve, Fig. 35, is opened as the pump nears the bottom of the well. This opens a passage for the accelerating charge and also for the additional ration of fuel necessary for full speed or power if the throttle is held open.

Economy. As the throttle is closed, the pump is lifted by the increased suction, so that the fuel flow is reduced for anything less

than full-load operation. This vacuum type accelerating and economizing system may be used to advantage with a governor. In this case the carburetor throttle valve is usually wide open, the speed being controlled by the governor valve. By "bridging" the governor with a suction line, the pump is actuated by the suction above the controlling governor valve and economizer action is thus retained.

Starting. The idling system acts as a priming device when the engine is at rest because the idling jet is submerged in the fuel that

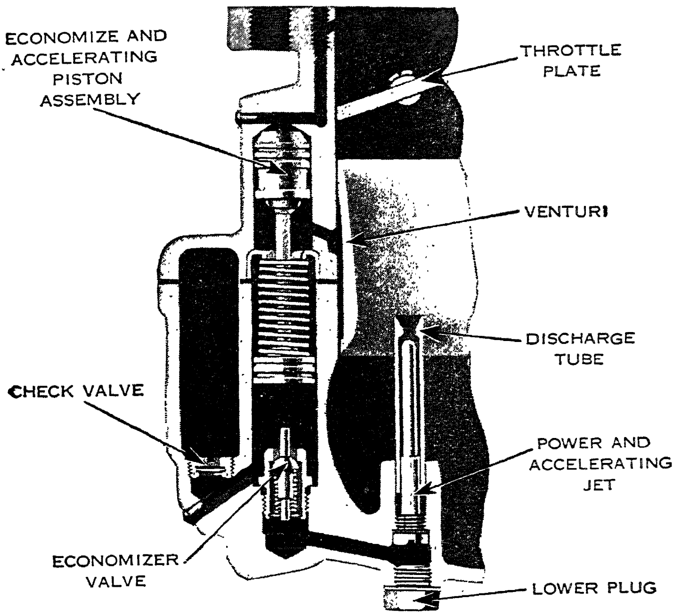


Fig. 35. Sectioned View of Zenith 150 Carburetor showing Accelerating Pump
Courtesy Zenith-Detroit Corporation

fills the well. The throttle should be slightly opened as this results in a very strong suction on the idling jet. The fuel passing at high velocity over the edge of the throttle plate is finely atomized and the high vacuum instantly vaporizes and mixes it with the air. This will ensure the first few explosions. With the usual manually-controlled strangler it is sometimes difficult to keep the engine running. To overcome this, Zenith uses a spring-loaded strangler.

The strangler shaft is off center so that the engine suction tends to pull it open. A spring tends to pull the strangler shut, but, except

at cranking speeds, the spring is the weaker of the two forces. Accordingly, as the engine is speeded up or slows down the strangler opens and closes, always being in a position to deliver just the right amount of air. This prevents over-choking and crank-case dilution and ensures continued running even in the coldest weather. Cold-room tests at zero temperature and experiences in the open air indicate that a car can stand all night at zero and be started and driven

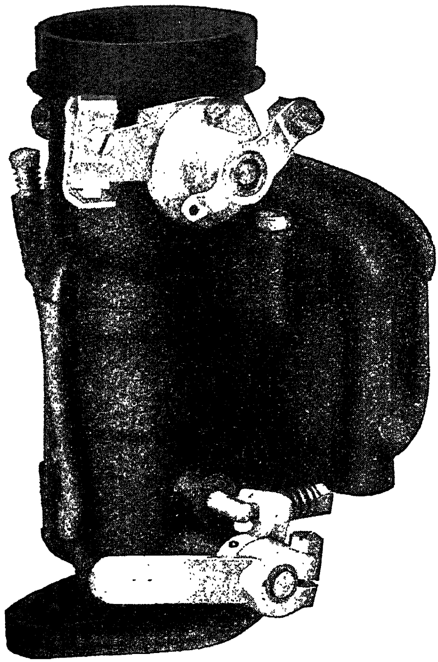


Fig. 36. Zenith Down-Draft Carburetor
Courtesy Zenith-Detroit Corporation

away with the engine firing regularly in less than half a minute. The strangler control is pulled out as usual for starting. It is left in this position or pushed in slightly until the engine warms up, then pushed in to the open position. No "jiggling" of the control is necessary.

ZENITH DOWN-DRAFT CARBURETORS

Model "IN-175." The Zenith compound nozzle system is used in the Model "IN-175" carburetor, Fig. 36. This consists of two jets,

the main jet and the compensating jet. (See Fig. 37.) The main jet varies with suction. Its tendency is to richness at top engine speeds. The compensating jet, unaffected by suction, has a tendency to leanness at top engine speeds. In combination, the rich and lean jets give an average mixture of correct proportions.

Carburetor Operation. An idling jet meters the fuel for idling while an idling adjusting needle controls the air. The idling tube

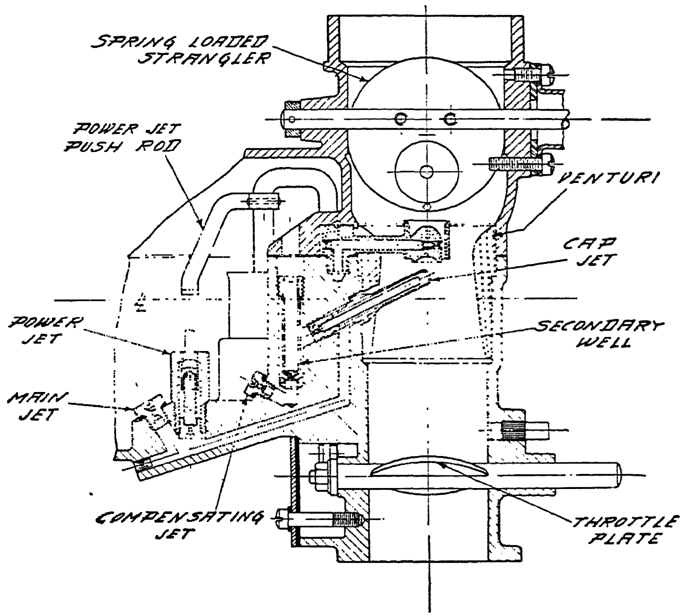


Fig. 37. Zenith Model IN-175 Mains and Compensating Jets
Courtesy Zenith-Detroit Corporation

carries this mixture to the discharge opening at the edge of the throttle plate. Idling speed is regulated by the throttle stop screw, Fig. 38.

Because full power requires a richer mixture than part throttle operation, the added fuel is provided by the power jet. The power jet valve is opened by the power jet push rod when the throttle is wide open. As the throttle closes from wide-open position, the push rod raises, thus permitting the valve to close and insuring economical metering for part throttle running. (See Fig. 39.)

Acceleration is provided for by a pump which is controlled by the movement of the throttle. The downward stroke of the pump piston forces fuel from the pump cylinder into the air stream through

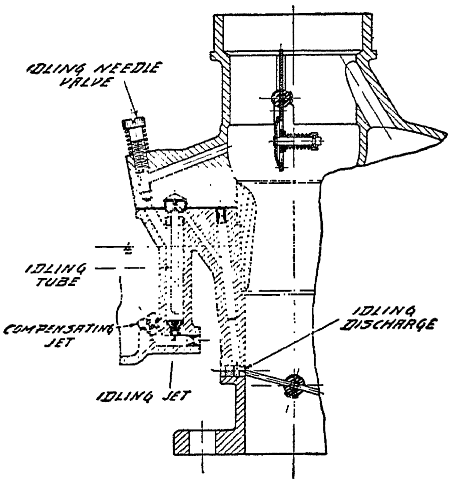


Fig. 38. Idling Position of Throttle
Courtesy Zenith-Detroit Corporation

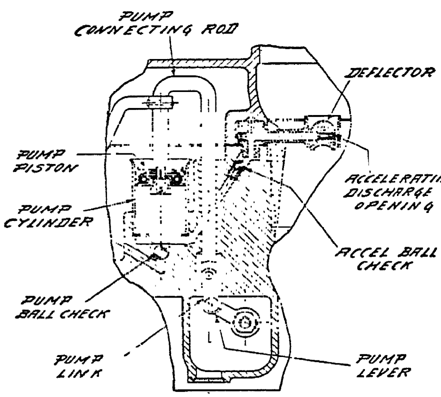


Fig. Power Jet and Accelerating Pump, Zenith Model IN-175
Courtesy Zenith-Detroit Corporation

the accelerating discharge opening. This furnishes the necessary additional fuel for flashy acceleration. (See Fig. 39.)

Starting. In starting the idling system acts as a priming device. With the throttle only slightly opened, there is a very strong suction on the idling system. Fuel passes at high velocity over the

edge of the throttle plate and is instantly vaporized as it mixes with the air stream. It is especially important to avoid over-choking in down-draft carburetion. Zenith uses a strangler with a by-pass valve which opens or closes with varying engine speeds, furnishing a combustible mixture until engine temperatures permit opening the strangler. The strangler shaft is off center so it may be satisfactorily operated by the automatic choke assemblies now used on many cars.

The fuel level should be $\frac{45}{65}''$ from the top edge of the float chamber when the carburetor is tested with $1\frac{1}{2}$ pounds pressure (equivalent of 6′ head). The chart of approximate settings provides

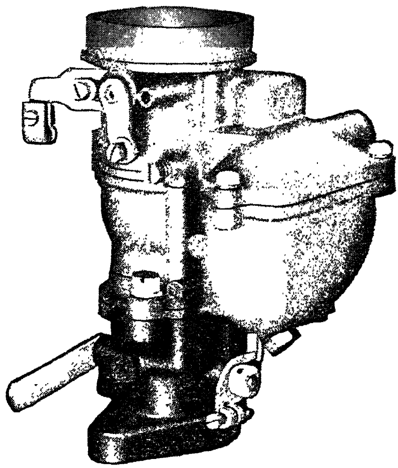


Fig. 40. Zenith IN-180 Down-Draft Carburetor
Courtesy Zenith-Detroit Corporation

the dealer with a jet combination to use in the absence of settings determined by actual road test. When a main jet adjustment is used, a main jet two sizes smaller should be used.

"IN-180" Series Carburetors. The Zenith "IN-180" Series carburetor, Fig. 40, has been especially designed to meet every condition encountered in down-draft carburetion. This includes provisions in design that insure positive, smooth idling, elimination of over-choking, and other difficulties already known to many users of down-draft carburetors.

The carburetor is a fully balanced down-draft instrument, incorporating an enclosed mechanical accelerating pump and vacuum

(or mechanical) economizer system, a special float construction, and other important features. Dirty air cleaners do not affect the mixture ratio. Marked accelerative ability, smooth operation, great range, flexibility, and, generally, fine operating characteristics are secured.

Carburetor Operation. The Zenith compound nozzle system is used. This consists of two jets, the main jet and the compensating jet as shown in Fig. 41. The main jet varies with suction. Its tendency is to richness at top engine speed. The compensating jet, unaffected by suction, has a tendency to leanness at top engine speeds.

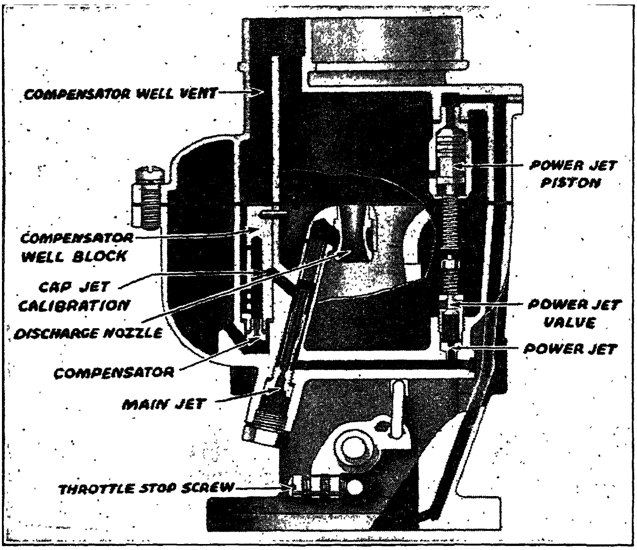


Fig. 41. Sectioned View Model IN-180 Zenith
Courtesy Zenith-Detroit Corporation

In combination, the rich and lean jets give an average mixture of correct proportions. To these a power jet is added which operates only when extra fuel is needed for development of maximum power. Under part throttle the suction (or vacuum) on the manifold side of the throttle is higher than when the throttle is wide open. This suction holds up the power jet piston assembly, permitting the power jet valve to remain closed, thus shutting off fuel from the power jet.

When the throttle is opened, the suction decreases, thus permitting the power jet piston to be opened by the pressure of its spring. The falling piston opens the power jet valve, permitting fuel to flow

to the power jet which is of a size to measure only enough additional fuel to develop full power.

Acceleration (see Fig. 42) is provided for by a pump which is controlled by movement of the throttle. The downward stroke of the pump piston forces fuel from the pump cylinder into the air stream through the accelerating jet. This furnishes the necessary additional fuel for flashy acceleration. An air vent controlled by a ball check valve, is provided between the pump and discharge open-

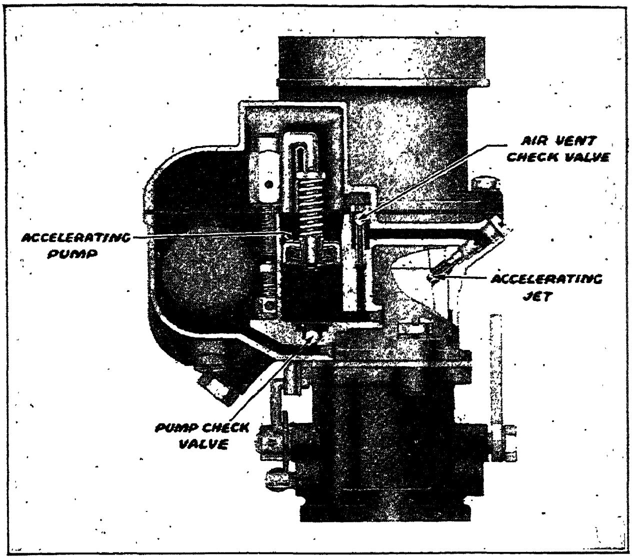


Fig. 42. Accelerating Pump and Float Chamber
Courtesy Zenith-Detroit Corporation

ing, to prevent the accelerating jet from supplying fuel except during the downward movement of the piston.

An idling jet, Fig. 43, meters the fuel for idling while an idling adjusting needle controls the air. The idling tube carries this mixture to the discharge opening at the edge of the throttle plate. Idling speed is regulated by the throttle stop screw.

In starting the idling system acts as a priming device. With the throttle only slightly opened, there is a strong suction on the idling system. Fuel passes at high velocity over the edge of the throttle plate and is instantly vaporized as it mixes with the air stream.

It is especially important to avoid over-choking in down-draft carburetion.

Zenith uses a strangler with a by-pass valve which opens or closes with varying engine speeds, furnishing a combustible mixture until engine temperatures permit opening the strangler. The strangler shaft is off center so it may be satisfactorily operated by the automatic choke assemblies now used on many cars.

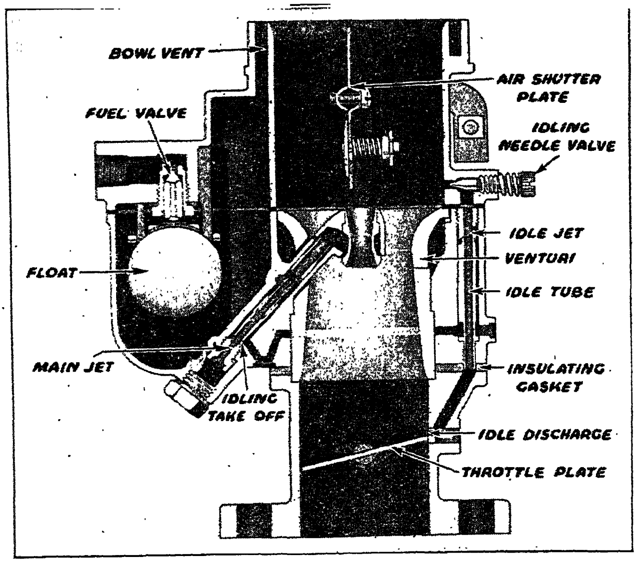


Fig. 43. Idling Tube, Needle and Throttle
Courtesy Zenith-Detroit Corporation

OLDSMOBILE 8-STROMBERG "EE-1" CARBURETOR

Main Metering System. Fuel enters the carburetor at the gasoline inlet *10*, Figs. 44 and 45, flowing through the float needle valve and seat *7-8* into the float bowl. Here it is maintained at constant level by float *6*. Air, which enters the carburetor through the air entrance at the top, places suction on the main discharge jet *3*, or idle discharge holes *14*, depending on the amount of throttle opening. The main metering jets *12* are of the fixed type. They control the flow of gas during the intermediate speeds of part throttle position up to approximately 75 miles per hour. From the metering jets the fuel passes into the main discharge jet *3*, where it is mixed

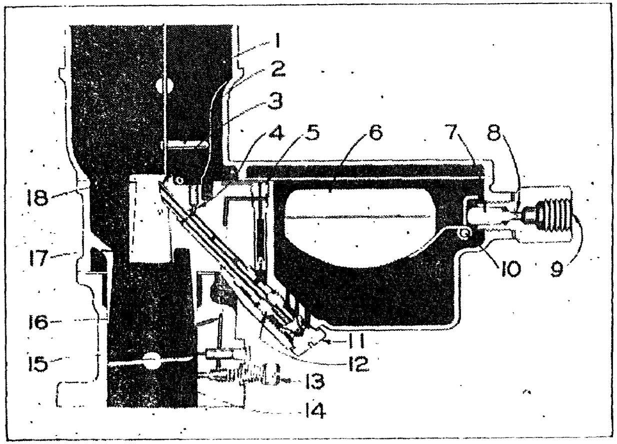


Fig. 44

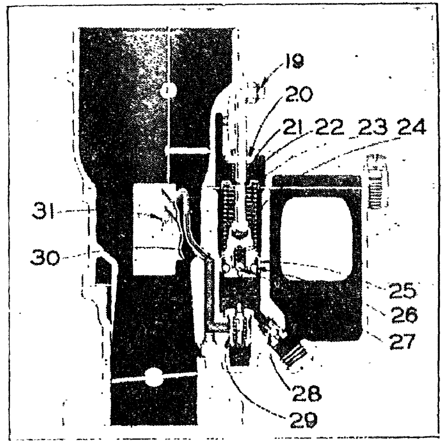


Fig. 45

OLDSMOBILE CARBURETOR

PARTS INDICATED IN ILLUSTRATIONS ABOVE ARE AS FOLLOWS:

1. Choke Valve
2. Choke Valve Stop Pin
3. Main Discharge Jet
4. High Speed Bleeder
5. Idle Air Bleeder
6. Float
7. Float Needle Valve
8. Float Needle Valve Set
9. Gasoline Inlet
10. Float Fulcrum Pin
11. Main Discharge Jet Plug
12. Main Metering Jet
13. Idle Needle Valve
14. Idle Discharge Holes
15. Throttle Valve
16. Mixing Chamber
17. Primary Venturi
18. Auxiliary Venturi
19. Pump Piston Link
20. Dust Washer
21. Dust Washer Spring
22. Spring Retainer Lock
23. Spring Retainer Washer
24. Pump Duration Spring
25. Pump Piston
26. Pump Piston Expansion Spring
27. Pump Relief Valve
28. Pump Inlet Check
29. Economizer By-Pass Valve
30. Pump Discharge Nozzle Holder
31. Pump Discharge Nozzle

IMPORTANT: When ordering venturi tubes, high speed bleeders, metering jets, main discharge jets or by-pass jets, etc., specify the size required, and always state type of carburetor with serial number; also the model and make of the car for which the part is intended.

with air from the high speed bleeder *4*, and then flows into the carburetor barrel, down to the intake manifold.

When the car reaches the speed of approximately 75 miles per hour, a richer mixture is required than that necessary for normal throttle opening. At this speed economizer valve *29* is forced down by piston *25*, allowing gas to flow through the economizer valve and discharging through restriction *31*. All gas from the economizer is controlled by this restriction.

All jets of the fixed type are calibrated at the factory to supply the correct mixture for normal operating conditions and should not be changed without special instructions. Fuel for idle speeds is drawn through the idle tube into a passage where it is mixed with air from the idle air bleeder *5*. It is then discharged through the idle holes *14*, depending on the amount of throttle opening.

Low Speed or Idling Adjustment. Allow the engine to warm up until the throttle returns to slow-idle. Idle needle valves *13*, Fig. 44, control the gas for low-speed adjustment. Turning OUT the needle gives a richer mixture, and turning it IN a leaner mixture. Turn the inner idling adjustment (the one toward the engine) in slowly until the engine begins to lag or run irregular, then slowly turn out until the engine begins to roll. Finally, turn in the adjustment very slowly again just enough so that the engine runs smoothly for this throttle opening. This adjusts the mixture to the four cylinders which are fed by the inner carburetor barrel. Adjust the outer idle adjustment so that its four cylinders fire smoothly. It may be necessary, after completing this adjustment, to cut down the engine speed slightly.

Accelerating Pump. For smooth rapid acceleration and flexibility, it is necessary to supply momentarily an extra amount of gas when the throttle is opened. On the up stroke of piston *25*, Fig. 45, gas is drawn through the inlet check valve *28*, into the pump cylinder. On the down stroke the compression closes the check valve *28* and forces open economizer valve *29*. The fuel is then discharged through the pump discharge nozzle *31*, into the carburetor barrel. When the throttle is opened part way, only a small amount of fuel is discharged. However, when the throttle is continuously held fully opened, gas flows steadily through the restriction. This gives the richer mixture that is required for maximum power.

Fuel Level. As previously stated, the fuel level in the float bowl is maintained by float *6*. The level is set at the factory at $\frac{15}{32}''$ below the surface of the float bowl. It is not necessary to change this unless extremely high test gas is used, or the carburetor is handled roughly. When necessary, it can be corrected by bending the float arm where it meets the float up or down to give the desired position.

STROMBERG PLAIN-TUBE CARBURETORS

The Stromberg engineers have always held to the plain-tube design in their product, the reason being, as they put it, that the carburetor when set up has the great advantage of "staying put" and maintaining efficient service over a long period.

In the plain-tube carburetor, the mixture proportion is maintained through the combination of the enriching and leaning characteristics of tube design. The double venturi arrangement, long popular with this carburetor, embodies the clean unobstructed form of air passage and gives a full range of high road speed with low-speed pulling ability. It is also designed to give an absolute maximum in torque at any average driving speed. The air-bled jet construction is responsible for the accurately governed fuel mixture through all speed ranges. This principle also gives good atomization and an even distribution of the fuel through the air stream.

The accelerating devices are the result of long seasons of experimenting and years of study of service conditions.

The idling operation of the carburetors is smooth and positive. The idling adjustments may be made without disturbing the high-speed range.

Warming-up controls have been the subject of much study, which has resulted in new devices which give a good range of engine flexibility and smoothness.

Steady Load and Acceleration. The demands placed on a carburetor vary considerably throughout the range of engine speeds and load conditions. The carburetor action which is satisfactory for average driving speeds is not the best possible arrangement for quick acceleration. Economy of gasoline at the average driving speed is secured by using a minimum amount of fuel. On the other hand, rapid acceleration may only be secured by using a richer

mixture made available simultaneously with the depression of the accelerating pedal. These conditions should be kept in mind when making a study of the simple sketches which are presented herewith.

When the student mechanic comes to a consideration of the actual carburetor models, both the requirements for driving at a steady rate under average conditions and the requirements for acceleration will be given consideration. The principles of the Stromberg plain-tube carburetor, as outlined here and illustrated in Figs. 46 to 54, deal only with the average operating conditions. The action of a plain tube is illustrated in Fig. 46. It will be noted that a venturi is in position over a plain jet, which is supplied with gasoline from a simple carburetor bowl. When the engine is in

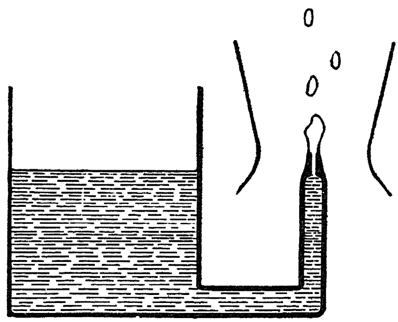


Fig. 46. Globules of Gasoline Will Be "Torn" from the Jet at Slow Speed

operation, the action of the pistons provides suction over the jet, with the result that the globules of fuel are drawn from the jet into the venturi tube. An arrangement such as the one illustrated in Fig. 46 might be so designed as to give fairly satisfactory operation over a speed of about 16 miles per hour and upward, but when the throttle is closed down to a slow engine speed—say below 15 or 16 miles per hour—the mixture will grow lean so rapidly that the engine will slow down and stop.

For instance if it were desired to have the engine operate at a speed of 10 miles per hour, the fuel jet would have to be increased 50 per cent in capacity. This would result in a corresponding increase in fuel delivery from 15 to 16 miles and upward. It will

also be found that it is impossible to have the engine idle properly no matter what the adjustment, because of the fact that the suction in the carburetor at extremely low speed is so weak that the fuel will not be lifted from the jet to the throttle. In order to prevent fuel overflowing at the jet it is necessary to design the float and needle-valve arrangement so that it will always stand at a level slightly below that of the top of the jet. This means that the amount of suction required to lift the fuel from the jet is considerable. At low engine speeds the fuel is likely to come out of the jet in large globules or drops.

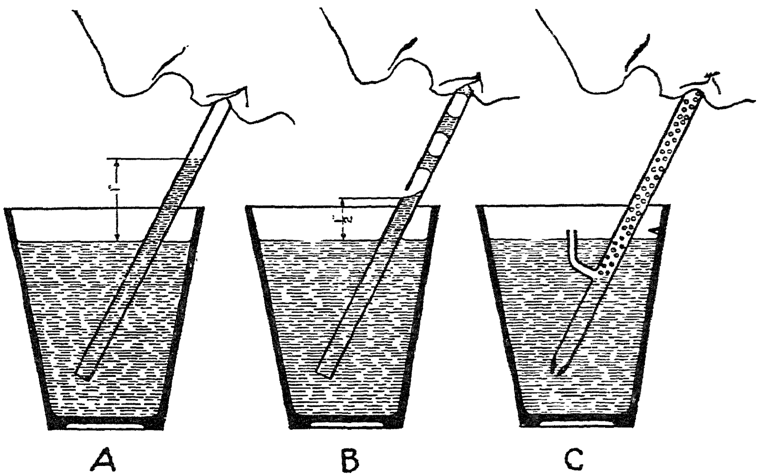


Fig. 47. Principle of Air-Bleeding a Jet

Action of Air=Bleed. The Stromberg application of the air bleed is illustrated in Fig. 47 at *C*. Just as a boy will use a straw to draw milk from a glassful, as shown at *A*, so may the carburetor action be considered. It will be noted that at *A* the fuel is being drawn without any air. However, if a small hole is placed in the straw, as shown at *B*, it will be noted that the same suction as before allows bubbles to enter and the milk will be drawn upward in a continuous series of drops. At *C*, illustrating the air-bleed principle, it will be noted that an additional tube has been set into the original tube or straw at a point somewhat below the top surface of the fluid. Suction on the tube now introduces a considerable

quantity of air along with the fluid. Since the lower end of the tube has been restricted, naturally the smaller the opening at the lower end of the tube and the larger the opening in the side of the tube, the more completely will the fluid be broken up and mixed with air as it is drawn from the vessel. It can be seen that a very fine calibration of the two openings must be arrived at when the principle is applied to a carburetor. The air-bleed must not be too large nor too small, neither must the calibrated opening at the end of the tube be out of proportion.

The arrangement just described, when incorporated into a carburetor jet, usually takes the form similar to that shown in Fig. 48. This type of jet will give a uniform mixture under steady speed throughout its range of operation. It has been learned that when

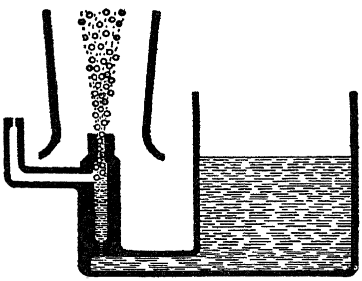


Fig. 48. Air-Bled Jet with Single Venturi

a mixture is desired which is slightly richer at low speed than at high speed, it may be obtained by making the air-bleed large or by confining the upper portion of the jet passage. This principle is made use of when a Stromberg carburetor is fitted to an engine, that is, the size of the main passage or main discharge jet is calibrated with extreme care to fit the characteristics of the engine being equipped.

Venturi Tubes. When a carburetor with a fixed size air opening is fitted to an engine, if the air opening is large enough to give the engine full power at high speeds, then the suction at the jet tends to be very low at low speeds. The use of a venturi-tube-shaped air opening gives the carburetor air capacity at high speeds while at the same time it gives higher velocity and increased suction at low speeds.

The Stromberg engineers make use of this principle as illustrated in Fig. 48 with a still further improvement in this direction, obtained by the use of a double or combined venturi tube, as shown. The air-bleed arrangement in connection with the double venturi ordinarily takes somewhat the form illustrated in cross section in Fig. 49.

Idling System. It is practically impossible to get a satisfactory idling speed if the main jet is depended on to supply all of the fuel. This is because of the fact that when the throttle is closed, as shown in Fig. 50, the suction below the throttle is relatively slight. On the other hand when the throttle is closed, as shown in Fig. 50, the suction above the throttle is at its highest. For this reason, the arrangement shown of providing a separate passage for

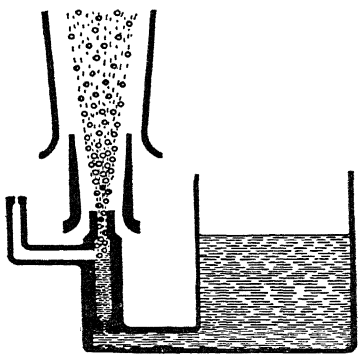


Fig. 49. Air-Bled Jet with Double Venturi

the fuel to a point just above the closed throttle is made use of. As shown in Fig. 50, the idling passage draws the fuel from the main jet so that no fuel can come through the idling system that has not already been metered through the main-jet system. At very low speeds the mixture is controlled by the idling orifices or openings. At higher speeds the mixture is controlled by the high speed orifices although a considerable amount of fuel may be going through the idling passage. Whether the fuel may be going through the idling passage or not depends upon where the suction is highest—at the idling passage or at the idling discharge jet. If the suction is highest at the small venturi, the fuel will spray from the main discharge jet; and if it is highest at the idling jet, more fuel will be drawn from

that point. Naturally, the greater the suction the more complete the atomization of the fuel drawn from the jet.

Gasoline Economizer. The air-bleed jet can be set to give a uniform mixture proportion at normal speeds and loads. By using large size air-bleed openings, it is also possible to obtain a graduation such that the mixture at speeds above 30 miles per hour will be quite a bit leaner than at lower speeds. Experiments have shown that with most engines a still further variation of mixture is necessary to give smooth operation throughout the entire range of speeds.

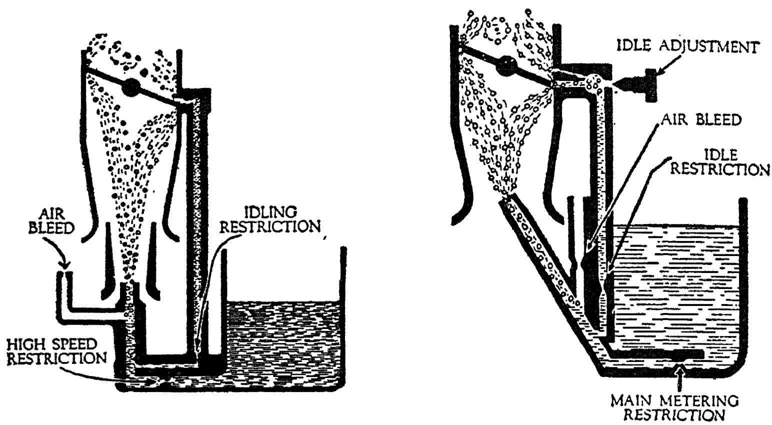


Fig. 50. Left —Model "O" Carburetor
Right—Model "U" Carburetor

The Model "O" idling jet is a single hole just above the closed butterfly throttle.
The Model "U" form makes use of one small hole just above the closed throttle and another one which is partially closed by the throttle valve at closed position.

If the fuel consumption is measured when the carburetor is in operation, with different carburetor adjustments, it very likely will be found that the lowest fuel consumption is obtained with a mixture so lean that, with any throttle position or any driving speed, the car speed will pick up a little when the mixture is made richer. In other words, the mixture which gives best economy is too lean for best power. With drivers educated to expect considerable snap and power from their cars, it is necessary to design the carburetor to make use of a little more gasoline under a pull or at high speed in order to get the full power of the motor. These same drivers when loafing along, with the throttle only partially open, are desirous of

having the best possible gasoline economy and so the carburetor is designed to give a leaner mixture for these loafing speeds.

Economizer Action. Since 1914, the Stromberg carburetors have been provided with a fuel economizer. This economizer action is designed to graduate the mixture so that with any given gasoline adjustment the mixture will be somewhat richer at the larger openings of the throttle than at the partially closed throttle positions generally used in driving.

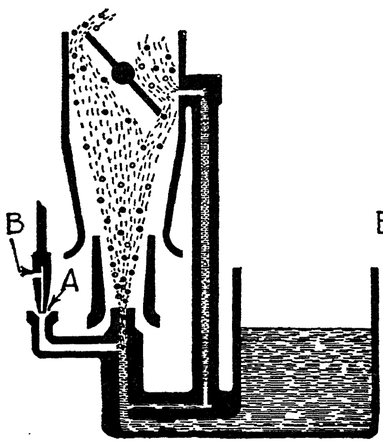


Fig. 51. Nearly Closed Throttle
The idle jet is in use and also the largest air bleed.

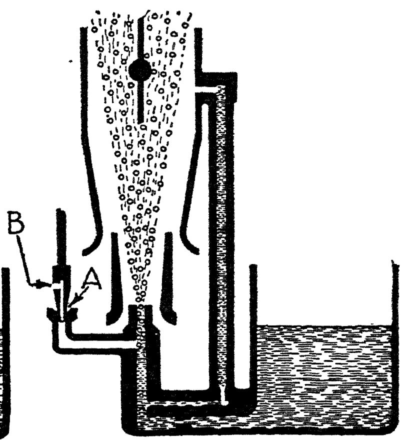


Fig. 52. Wide-Open Throttle
The idle jet is out of use and the air bleed is partially closed.

In certain models of the Stromberg carburetors, the economizer action is obtained by varying the size of the air-bleed opening as shown in Figs. 51 and 52. From idle up to about one-third of the throttle opening (which really gives more than half the air capacity of the carburetor), the economizer needle is raised from its seat, as shown at *A* in Fig. 51. This allows a relatively large amount of air to enter the fuel jet to break up the fuel and emulsify it. As the throttle is opened, the economizer needle will seat, as shown at *A* in Fig. 52. This results in reducing the size of the air-bleed opening to that of a very small hole (drilled through the needle point plug in the vertical carburetors). In the case of the horizontal models, it is reduced to the size given by the external bleeder plug. This arrangement will give a leaner mixture with the throttle closed

and the needle raised, as shown in Fig. 51, than it will with the throttle fully open and the needle *A* closed, as shown in Fig. 52.

High-Speed Air Bleed. The air-bleed opening when the economizer needle is seated is known as the high-speed or compensating bleed and its size is selected according to the richness of the mixture desired at wide open throttle throughout the range of car speeds; but when determining this size, the car should be taken to a hill which will hold it down to a low speed, preferably not over 15 miles per hour, and the proper gasoline needle seating obtained. The car should then be tried for full speed and a high-speed bleeder size used that will give the best mixture at maximum speed with the same gasoline needle setting which gives best power on the hill.

Economizer Reducer. The amount of economizer action is controlled by the amount of air which is admitted to the jet when the economizer needle is raised and this may be regulated by the economizer reducer. See Fig. 55 for an arrangement of this. In finding this size, the gasoline adjustment is set to give the best power on a hill that will hold the car down to a speed of 20 to 25 miles per hour. The size should then be selected to give a mixture which is so lean at part throttle opening that the gasoline needle adjustment—as found on the hill—cannot be cut down one notch without causing the motor to fall away in speed for a given partial throttle opening. In all cases the size of the economizer reducer should not exceed the size of the main discharge jet opening.

On the Model "U" Stromberg carburetors, the desired enrichment at half- to full-open throttle position is obtained by means of a gasoline valve, Fig. 55. With this type, the main metering jet size is selected for best economy at closed throttle; the economizer by-pass jet is then selected of such size as will give full power and the best operation at full-open throttle. On some of the models, the economizer needle valve is opened mechanically by the action of the same arm that operates the acceleration pump, as shown at *A* in Fig. 55. On certain other models, the economizer needle valve is operated according to the intake manifold vacuum, which in turn depends upon the engine load. At idle and light loads, the vacuum economizer piston is sucked up against a spring. When the throttle is opened or a heavier load placed on the engine, the manifold vacuum drops and the spring pushes the piston down to open the

economizer needle valve, as shown at *B*. The fixed air-bleed opening is known as high-speed or compensating bleed, and its size is selected according to richness of mixture desired at wide-open throttle.

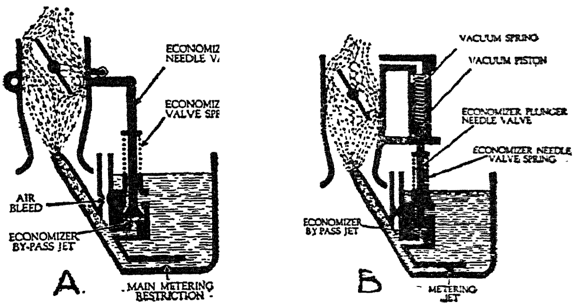


Fig. 55. Gasoline Valve Economizer
A—Mechanical-Operated Form
B—Vacuum-Operated Form

Model "U." This type operates on the plain-tube principle and constructional features as developed by the Stromberg engineers. A special form of accelerating pump is perhaps the chief feature of difference in Model "U" over Model "O." In smaller sizes of this series a single venturi tube is used and an inclined main discharge jet is usually fitted with fixed size metering jets, also called cup jets, and it also incorporates a gasoline economizer.

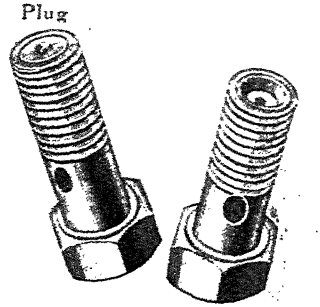


Fig. 56. Main Metering Jets Used in the Stromberg Model "U" Carburetor

The lower idle discharge hole is almost entirely below the throttle valve when the valve is entirely closed. The air-bleeder size is taken as constant and the required adjustment of mixture range is obtained by varying the size of the main discharge-jet bore. Three types of high-speed fuel regulation are employed in these carburetors. A high-speed metering jet generally used has a sharp-edged thin-plate metering orifice formed as a small cup pressed in its tip. These jets are usually used on six-cylinder engines and are called cup jets, Fig. 56. Another

form of metering jet, which is used on the four-cylinder engines and for twin carburetors, as would be the case with eight-cylinder engines, contains a plug or bushing in its end. It has a longer metering orifice with beveled ends and is called a plug jet.

These two types of jets have different characteristics and must not be confused. The jets are marked according to their orifice diameter in thousandths of an inch and have all been tested to see that their fuel delivery is up to standard. Make very certain that the two types of jets are not confused when servicing carburetors. The plug jet delivers much more fuel than the cup jet and has a characteristic of giving a richer mixture in proportion at high suctions.

Economizer Action. In the Model "U" carburetors, economizer action is secured by a submerged gasoline valve, operated by vacuum from the pump arm as the throttle is opened wide. See Fig. 55. Its fuel delivery or amount of economizer action is determined by the economizer restriction or by-pass jet, which has a "cup" form of metering orifice pressed in its tip. In setting these carburetors, the high-speed metering jet or needle setting is selected to give most economical smooth running in the part throttle range. If this mixture ratio is then found to be too lean at wide-open throttle and full load, a by-pass jet is put in of the size necessary to give the added enrichment.

Accelerating Pump. The chief characteristic of these later carburetors is the Stromberg design of accelerating pump, which possesses the advantage of giving a positive and definite accelerating charge regardless of the suction which may exist in the manifold and carburetor. This charge is delivered as a momentary spurt of fuel, followed by a sustained discharge of fuel lasting several seconds. The first spurt of fuel is rather geyser-like in action. The sustained flow of fuel is somewhat less but continues over an appreciable time. The amount of this charge is automatically reduced as the temperature within the engine compartment is increased.

The accelerating device in its several stages of operation is illustrated in Fig. 57. It consists of a cylinder with its upper end closed. This cylinder is forced downward by a lever as the throttle is opened. Within the cylinder is a piston, which slides on a vertical stud. When the throttle is in fixed position, the piston is seated against the conical end of the stud, as shown at *A*. This closes the

gasoline passage to the main discharge jet. When the throttle is opened and the pump cylinder suddenly depressed, the piston is forced down by the gasoline trapped above it and a quick spurt of fuel is delivered through the stud opening to the main discharge jet, as shown at *B*. As the throttle is held in this position, the piston slowly rises under the force of its spring. This is the action which delivers a further accelerating charge at a gradual rate into the main discharge jet. In certain of the Model "U" carburetors the amount of normal accelerating fuel charge is governed by the size of the hole in the head of the stud, while in certain other models a gasoline reducer plug is threaded into the passage between the stud and main discharge jet. The size of these jets varies between

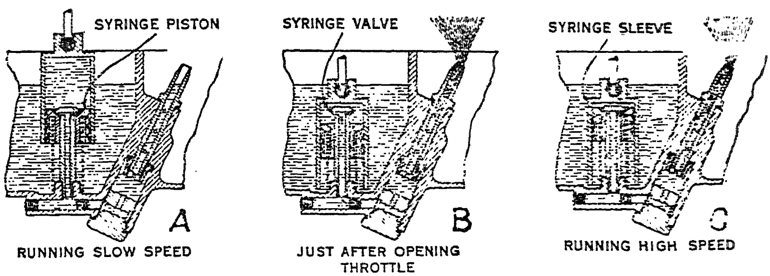


Fig. 57. Action of Stromberg Accelerating Pump

No. 56 and No. 68 drill size and the delivery of the pump is measured as the number of cubic centimeters of gasoline that will drain into the air horn when the carburetor is set up vertical on a stand under normal fuel head and the throttle opened ten times in succession. The flow required with different engines at different seasons varies from 3 cubic centimeters in ten strokes of the pump to 30 cubic centimeters. Naturally in warm weather when the temperature becomes high under the hood and the temperature of the carburetor likewise is high, gasoline vapor is liberated from the body of fuel within the float chamber. The cylinder space of the pump becomes partially filled with this vapor, thereby automatically reducing the amount of the accelerating charge.

When determining the proper pump setting, the hole in the top of the stud or the reducer in the pump passage should be increased

as necessary to improve the response to the throttle with engine fairly cool. The action of the carburetor should then be tested with the engine warm, at a temperature of 140 degrees Fahrenheit or more under the hood, to make sure that the response of the engine does not become sluggish from too much gasoline when the throttle is opened from idle.

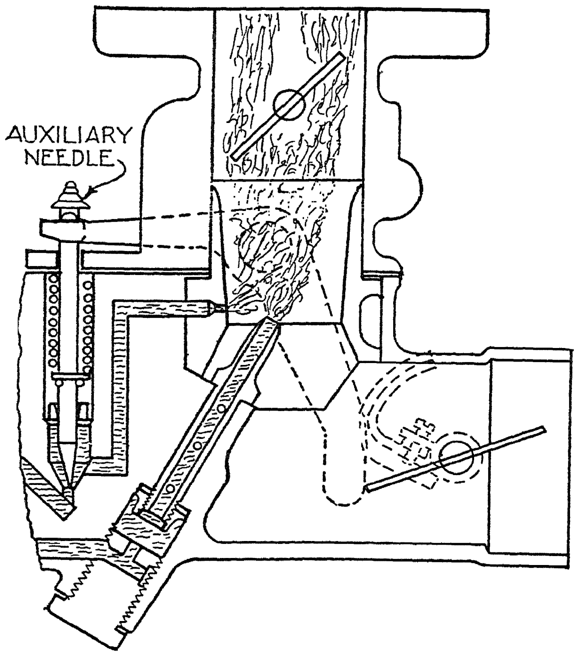


Fig. 58. Auxiliary Needle in Stromberg Carburetor
When the choker is pulled out, the choker valve cam strikes the lower end of a bell crank which raises an auxiliary needle and opens a gasoline passage to the venturi as an aid in starting.

Starting and Warming Up. Have the engine well warmed up so that the intake pipe above the carburetor is at least warm to the hand, then slow the engine down until minimum steady idling speed is reached. Then turn the low-speed adjustment very slowly to the right or left until the steadiest running and fastest running for that throttle position is obtained. This adjustment operates on air so that screwing it in gives a richer mixture and screwing it out gives a leaner one. If after this adjustment is made

the engine idles too fast, turn the throttle stop screw counter-clockwise to reduce the minimum throttle opening until the desired idling speed is reached. If the engine idles too slow, as would be indicated by its rolling sound and easy stalling, then screw the throttle stop screw inward or clockwise to increase the minimum idling speed. With the engine idling properly, there will be a steady hiss in the carburetor. In case this hiss is not even, the auxiliary control needle, Fig. 58, may not be seated. In order to secure proper idling speed on present-day fuel, the gap between the spark-plug points must not be less than .022 inch nor more than .028 inch if wide-open throttle operation will permit.

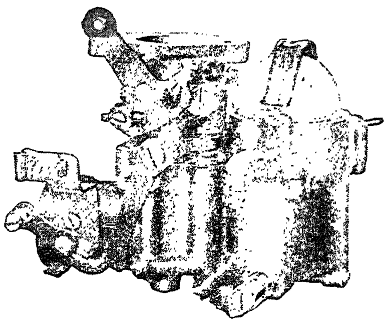


Fig. 59. Exterior View [illegible] "U" Carbure[illegible] Gas Feature

With the instructions which are given in order that the car driver may secure proper operation from his carburetor when starting, include the following suggestions:

When the engine is warm, simply throw on the switch, step on the starter and at the same moment depress the accelerator pedal slightly. In moderately cold weather the throttle lever on the steering wheel is opened slightly until the accelerator button can be felt to move downward. Pull out the choke button on the dash from $\frac{1}{8}$ inch to $\frac{3}{8}$ inch, turn on the ignition switch, and depress the starter button until the engine starts. In cold weather the throttle should be opened the same amount or a little more, the switch should be put on and the starter button simultaneously depressed, and at the same time the control should be pulled out all the way and held there from one to five seconds. As the engine begins to fire,

return the control gradually, opening the throttle a little further in case the engine is very cold. Owing to the choke valve and auxiliary needle connection, shown in Fig. 58, the engine will be flooded if it is cranked with the dash control pulled all the way out for ten to fifteen seconds. If flooding results, allow some time for the accumulated gasoline to drain out and try cranking with wide-open throttle.

Float Level Adjustment. The gasoline level in the float chamber should be set with the float level $\frac{9}{16}$ inch below the gasket face of the float chamber except in the case of the Model "UX-4," where the distance is $1\frac{9}{32}$ inch. In other words, the gasoline level with the engine idle should be $\frac{9}{16}$ inch below the top of the float bowl. If the float is low, bend the arm so as to move the float upward toward the float-chamber cover the same distance as the level needs correction—that is, to raise the level $\frac{1}{16}$ inch, bend the float up $\frac{1}{16}$ inch; to lower the level, hold the float arm tight where it touches the needle and bend the float downward away from the float-chamber cover.

Stromberg Vis-a-Gas. A number of the Stromberg carburetors, notably the Model "U," are fitted with the Stromberg vis-a-gas. This little device has a transparent cover which goes over the carburetor bowl and contains within it a gasoline strainer. Every drop of gasoline entering the carburetor is strained of dirt and impurities, thus preventing the clogging of the small orifices and jets in the carburetor. This device may easily be drained or cleaned. It is shown in position on the Model "U" in Fig. 59.

STROMBERG DUAL OR TWIN CARBURETORS

Model "OO." The Model "OO" carburetor is made in the $1\frac{1}{4}$ inch size only and is used on certain eight-cylinder cars. It has a single high-speed needle adjustment, which regulates a fuel orifice in series with two metering jets, each of which feeds one barrel of the main discharge jet. The idling adjustments, which are individual for each barrel, are different from other models in that they employ needles regulating the upper idle discharge hole at all times, which is above the throttle valve and thereby regulates the mixture from the minimum idling speed up to about ten miles per hour. The mixture from 10 to 18 miles per hour is regulated by the size of the fuel and air-bleeder orifices in the idling tubes. This construction allows a very close adjustment on the idles, as has been found necessary with

dual carburetors. A single accelerating well is used with individual outlets to the small venturi in each barrel. The accelerating well is usually fitted with the thermostat control.

Model "OO" is illustrated in Fig. 60. The instructions as given for the adjustment of dual carburetors, Model "UU," are also applicable to this carburetor.

Model "UU." The Model "UU" has the same float mechanism, venturi tubes, main discharge jets, and idle systems as the Model

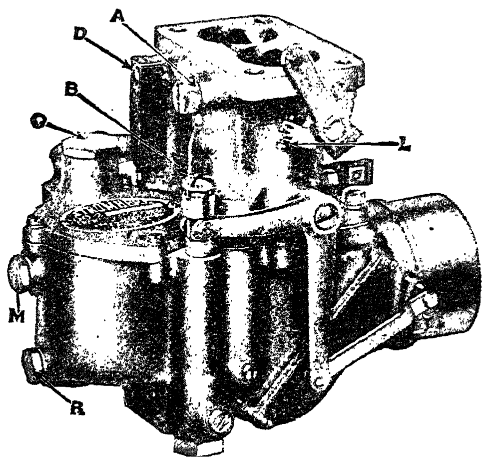


Fig. 60. Stromberg Twin-Type Carburetor—Model "OO-2"

"OO" but carries the accelerating pump and economizer similar to the Model "U" series. A needle adjustment is supplied to control the pump action, its setting ranging from one-half turn open in the summer to three turns open in the winter. Plug type metering jets of the Model "U" series are employed. These are shown in Fig. 56.

Idling Adjustment. With the dual carburetor the idling adjustment is somewhat sensitive, due to the fact that the throttle cracks only about .003 inch wide when the engine is idling. This is approximately half that needed with a single carburetor of the same capacity. These idle adjustments regulate the fuel so that screwing them out gives a richer mixture and screwing them in gives a leaner mixture.

With the engine at a normal operating temperature, retard the spark halfway and screw the inner idle adjusting needle (the one toward the engine) all the way into its seat. This cuts off the gasoline supplied to the four cylinders fed by the manifold branch above the inner carburetor barrel and will cause the engine to slow down considerably. Both of the idle adjustment screws are marked *A* in Fig. 61. This action cuts off the gasoline to the four center cylinders, that is, cylinders 3-4-5-6 which are fed by the inner carburetor barrel.

Next proceed to adjust the outer idle adjustment needle so the four outside cylinders 1-2-7-8 will fire smoothly. Allow the needle to remain in this position.

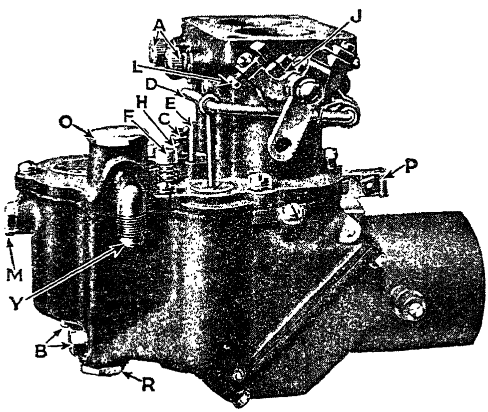


Fig. 61. Stromberg Twin or Dual-Barrel Carburetor—Model "UU-2"

Next open or unscrew the inner idle adjustment until all eight cylinders begin to fire and the position for smoothest operation for cylinders 3-4-5-6 has been found. Allow the needle to rest at this point.

Recheck the outer needle *A*, cutting it down slightly when the adjustment has been found for this needle. Allow it to remain. Preferably the adjustment should be slightly rich for each of the two needles.

If after the idle speed adjustments have been made the engine runs too fast, turn the throttle stop screw *L* counterclockwise to reduce the minimum throttle opening until the desired idle speed is

reached. If the engine idles too slow, as would be shown by the rolling sound or stalling action, the throttle screw should be screwed inward or clockwise to increase the minimum idling speed.

When the engine is idling properly, there should be a steady hiss in the carburetor. If the hiss is unsteady, the auxiliary control needle *C* may not be seating.

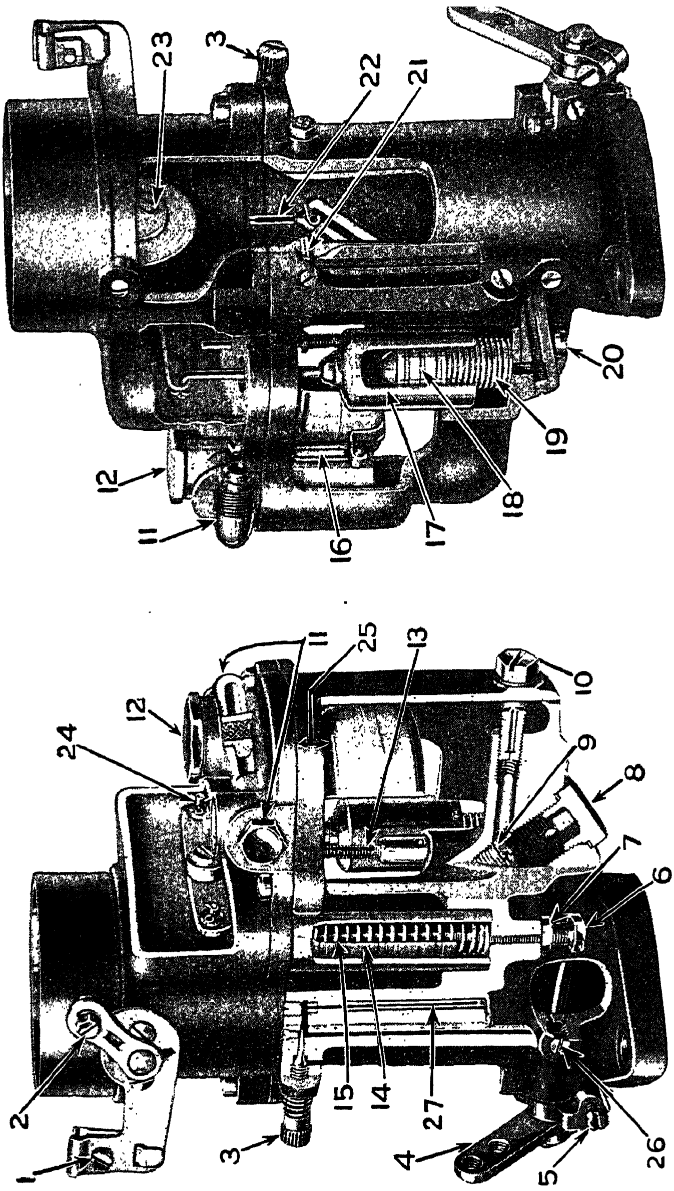
The suggestions for starting and warming up as given for the Model "U" carburetor apply with reference to this carburetor.

Float Level Adjustment. The gasoline level in the float chamber should stand, with the engine idle, even with the bottom of the level sight hole *M*, Figs. 60 and 61. As the engine is raced to high speed, the level will naturally fall. If the carburetor floods continuously, remove the strainer plug *O*, clean the strainer, then replace and flush out the float chamber by turning on gasoline full with drain plug *R* removed. If flooding continues after this, take off the top of the float chamber and float mechanism with it and inspect the needle valve point and needle valve seat. Tapping the needle valve into the seat with a screwdriver handle, while rotating it in several positions, will sometimes give good results. In case the needle valve point shows wear, it should be replaced.

If, after the above treatment, the fuel level, when sighted through the opening *M*, stands above or below the bottom of the level sight hole, readjustment may be made by bending the lever arm in the corner between where it touches the float needle and where it meets the float body. The factory setting for the float of these carburetors is $\frac{7}{32}$ inch from the top of the float to the bottom face of the float chamber cover, when the float needle is seated.

STROMBERG DOWN-DRAFT CARBURETOR

Model "D." One of the latest developments in the carburetor field is the application of the down-draft principle. The proper application of the idea secures a more complete distribution of the fuel. The Stromberg down-draft carburetors incorporate the well-known and long-used plain-tube principles. All of the theory as given herein covering the Stromberg models has application in and understanding of the operation of the Model "D," illustrated in Fig. 62. The Model "D" incorporates the following principles:



1.—Choke Control Tube Holder. 2.—Choke Lever Wire Clamp Screw. 3.—Idling Needle Valve. 4.—Throttle Lever. 5.—Throttle Stop Set Screw. 6.—Pump Adjustment Screw. 7.—Vacuum Piston Stop Screw Lock Nut. 8.—Main Discharge Plug. 9.—Main Discharge Jet Retainer Plug. 10.—Main Metering Jet. 11.—Gasoline Connection. 12.—Strainer Plug. 13.—Economizer Needle Valve. 14.—Vacuum Piston. 15.—Vacuum Piston Spring. 16.—Float Needle Valve and Seat. 17.—Pump Piston Sleeve. 18.—Pump Piston. 19.—Pump Piston Spring. 20.—By-Pass Metering Jet (Economizer). 21.—Pump Discharge Nozzle. 22.—High-Speed Air Bleeder. 23.—Choke Valve (Flapper Type). 24.—Pump Piston Link. 25.—Float Setting. 26.—Idle Discharge Plug. 27.—Idle Tube.

Fig. 62. Sectional Views of the Stromberg Type of Downdraft Carburetor

1. A semi-automatic choking device for starting.

2. A positive acting accelerating device, consisting of a syringe pump which delivers an accelerating charge immediately the throttle is moved and meters and delivers this charge over a definite period of time.

3. An adjustment to vary the quantity of accelerating charge, according to climatic conditions.

4. Idle and low-speed jets below the throttle, with separate idle adjustments for smooth low-speed performance.

5. An economizer which permits the carburetor to operate on a very lean and economical mixture and which automatically shifts to the needed richer setting when the full power of the engine is called for.

Starting and Warming Up. The usual procedure for starting in cold weather is to open the throttle about one-third the way. Next throw on the ignition switch and pull the choker out all the way. Then step on the starter button. Hold the choker out all the way until the engine starts, then open the choker by pushing in the control slowly, while at the same time the throttle may be closed slightly, thus having the engine operating at a fairly fast speed. Continue to adjust the choker until the engine runs smoothly and allow the engine to warm up slightly before attempting to operate the car. When the dash control is all the way out, it is essential that the choke valve in the carburetor entrance be closed completely. If trouble is experienced in starting, inspect the connection and note whether this condition is secured.

NOTE: When the engine is warm and it is desired to start it immediately, open the throttle to about a thirty-mile per hour position, turn on the ignition switch, and step on the starter. If a start is not made immediately, pull the choker control out for an instant and immediately push the choker control in again to normal position. This will prevent flooding the hot engine.

Float-Level Adjustment. When the engine is not running, the proper gasoline level is $\frac{7}{8}$ inch below the top of the float bowl. The proper setting for the Model "D," shown at *25* in Fig. 62, is $\frac{23}{64}$ inch from the lower surface or gasket face of the cover to the top of the float at its center. Bend the float lever arm in the corner to correct the setting, bending it an amount equal to the correction desired.

Low-Speed Adjustment. If the carburetor adjustment has been tampered with or destroyed for any reason, the first thing to do is to have the engine well warmed up so that the intake pipe above the carburetor is approximately 120 degrees, which will be quite warm to the hand. Slow down the engine by means of the throttle lever on the steering wheel until the steady minimum idling speed is reached. Turn the low speed adjustment *3* in Fig. 62 right and

left until the steadiest running and fastest running for that throttle position is obtained. Turning this adjustment in gives a richer mixture and turning it out gives a leaner mixture. Secure the best operation for the throttle opening and if this should be too fast for idling, it will then be necessary to adjust the small throttle stop screw *5* by turning it counterclockwise to reduce the minimum throttle opening. In case the engine would be too slow, as would be indicated by its rolling and stalling easily, then the screw should be turned inward until the proper idling speed is secured. If this does not give a proper idling speed, remove plug *26* and see that the two holes near the lip of the throttle valve are open and clean. Also remove idle tube *27* and see that the small hole in the end is open and that air can be blown through the tube. Use extreme care in handling these parts so as not to enlarge any of the orifices and thus destroy the calibration.

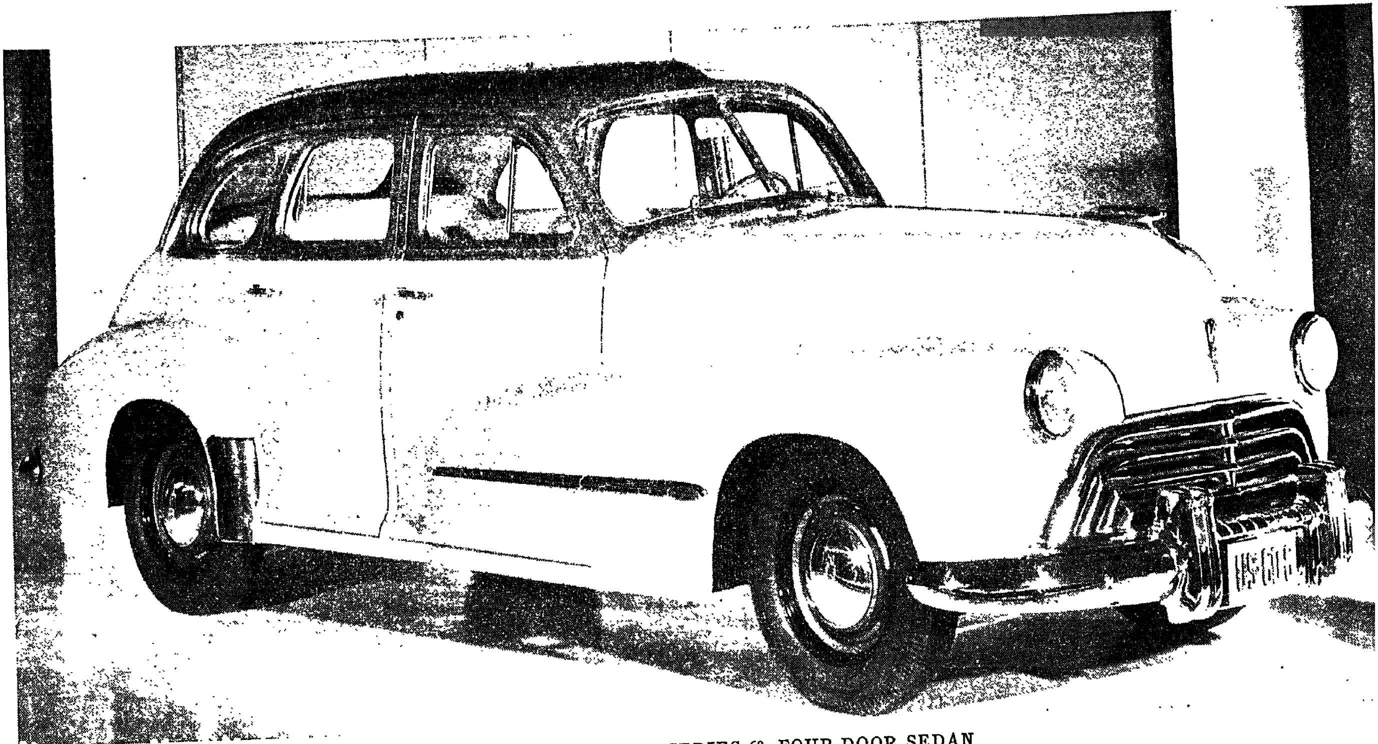
Intermediate Speed. The fuel mixture at intermediate speed is controlled by the size of the main metering orifice *10* in Fig. 62. The size of this orifice is stamped on the outer face of the jets in decimal parts of an inch. It is not likely that this size will need to be changed except in cases of damage, when parts should be replaced. On wide open throttle, an additional quantity of fuel is supplied by the by-pass metering jet *20*.

Accelerating-Pump Adjustment. The pump adjustment screw *6*, Fig. 62, controls the quantity of fuel which is delivered by the accelerating pump. The normal factory settings do not ordinarily need to be changed. In hot weather the accelerating pump discharge may be reduced by turning the screw up or to the right and in winter the quantity may be increased by turning the screw to the left or down. Loosen lock nut *7* before adjusting and tighten it after making the adjustment.

Lincoln-Zephyr Carburetors. This carburetor is of the dual down-draft type, made by Stromberg, with an accelerating pump which allows rapid acceleration. The carburetor also has an auxiliary valve choke. All orifices are of the fixed type, excepting the idling jets which are controlled by the idling adjusting screws. The idling speed of the engine is controlled by the throttle stop screw, and should be so adjusted that the engine speed is equal to a car speed of five miles per hour.

To make the idling adjustment, the engine should be thoroughly warmed up, and there should be no air leaks at the intake manifold to cylinder connections or at the windshield wiper, or distributor vacuum connection. The idling adjustment screws are found below the float chamber. The idling adjustment controls the proportion of gasoline-air mixture being fed to the engine for low speed operation. For a richer mixture the screws are turned out, while turning them in gives a leaner mixture. One side of the carburetor should be adjusted at a time. Turn the idling adjustment screw slowly inward until the engine begins to run irregularly or starts to lag, then turn the screw slowly out until the engine tends to roll with the rich mixture, then slowly turn the screws inward just enough to make the engine run smoothly. The other side should be adjusted in like manner. After this adjustment is made, it may be necessary to correct the idling speed of the engine to the five-mile an hour setting by the throttle stop screw.

Oldsmobile Carter Carburetors. On the recent Carter carburetors as fitted to the Oldsmobile cars, a device called an anti-percolator has been fitted. This device prevents fuel being forced through the main jets into the intake manifold by the heat of the motor after hard or fast driving, which causes the fuel to boil and makes the fuel flow through the main nozzle into the manifold. This excess gasoline in the manifold is the cause of hard starting with a hot motor. If hard starting is experienced under the foregoing conditions, the anti-percolator adjustment should be carefully checked. To check this adjustment, set the throttle valve with .020 inch between the throttle valve edge and the throttle bore on the side opposite the port. The lift on the pump arm on the six cylinder, and the metering arm on the eight cylinder, should be adjusted to allow .005-inch to .015-inch clearance between the valve stem and the lip. As there are two anti-percolator devices on the L-36 carburetors, they must be adjusted equally. In doing this, the setting of the metering rods must not be changed. Carefully check the setting of the anti-percolating units after the metering rods are installed.



1946 OLDSMOBILE SIX, SERIES 60, FOUR-DOOR SEDAN
Courtesy of Oldsmobile Division, G.M.C.

CARBURETORS

PART II

FORD CARBURETOR

Model "A." The Ford Model "A" carburetor is of the plain-tube type. There are two adjustments to the carburetor, one being provided for slow-speed adjustment and the other for high-speed adjustment. In addition to this there is a provision for choking, this provision being in combination with the high-speed nozzle adjustment.

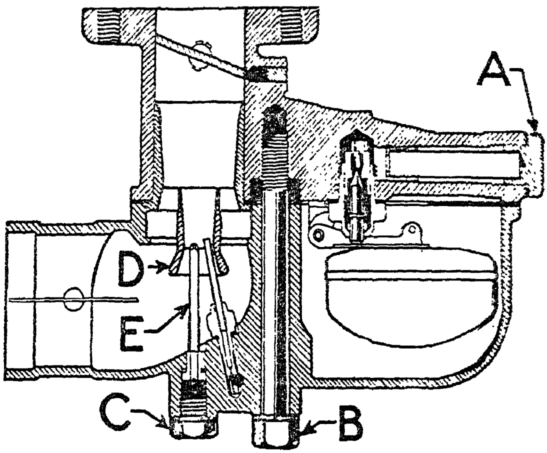


Fig. 65. Sectional View of Ford Model "A" Car Carburetor

Referring to Fig. 65, it will be noted that gasoline enters at the point *A*, flows through a screen, and drops into the float chamber. As the float rises on the gasoline, the level is automatically controlled. The air choke for starting is embodied in the carburetor in the air passage. The main gasoline jet *E* is located in the venturi *D*. It will be seen that if the butterfly valve in the air intake is turned across the air passage, that a very considerable suction is induced around the main gasoline jet *E*.

As in most plain-tube carburetors, it will be noted that there is a primary and also a secondary venturi. The larger venturi is the primary and is located just under the throttle valve.

Cleaning Carburetor. If the carburetor performance is not all that is expected, the filter plug *A* should be removed and the screen lifted out. Any dirt may then be blown out with the air line and the passage rinsed out with gasoline. If this does not cure the trouble, it will be necessary to disassemble the carburetor. In order to do this, remove the main assembly bolt *B*, Fig. 65, and carefully separate the parts to avoid damage to the gasket, float, and

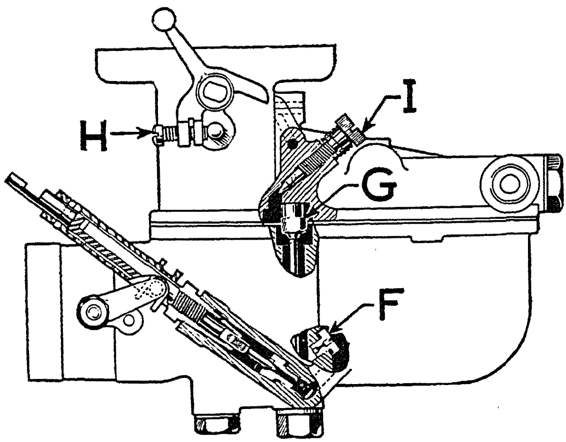


Fig. 66. Adjustments on Ford Model "A" Car Carburetor

idling jet tube. Next remove the plug *C* below the main jet *E* and use air to blow out dirt and rinse with gasoline to remove any dirt in the bowl or jets. Use extreme care to see that all parts are reassembled in proper position.

Testing Carburetor. It is a generally recognized fact that it is impossible to adjust the carburetor on a new engine until such time as the engine has been run in. The gasoline consumption will be higher for a time for this reason.

When adjusting the carburetor for economical performance, it is imperative to have the engine warm. In many instances it is necessary to adjust the carburetor for driving conditions where it is

seldom that the engine is thoroughly warmed up. This would be the case in city driving for short distances with many stops.

Idle Adjustment. The ignition of the engine should be in first-class condition and the ignition timing should be properly set. The first step in adjusting the carburetor is to retard the spark fully. Next adjust the throttle adjusting screw *H*, Fig. 66, until the engine will turn over at a fair rate and not stall. Then turn the idle adjusting screw *I* in or out until the engine operates smoothly and shows no signs of stopping or galloping. After this adjustment has

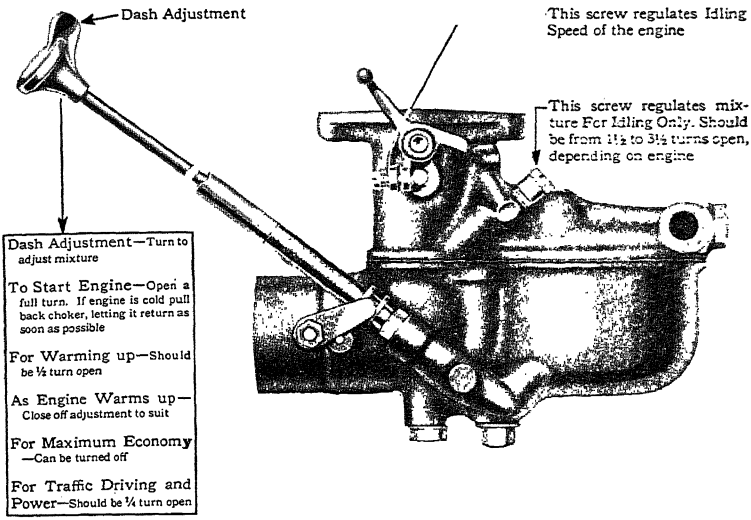


Fig. 67. Chart of Adjustments on Ford Model "A" Car Carburetor

been made, the next step is to reset the throttle *H* until the engine idles at the desired speed. This speed is usually found when the idling screw *I* has been turned two or three turns off of its seat

Dash Adjustment. The dash adjustment, Fig. 67, is a choke and screw adjustment. The choke is spring returned so that after the engine is started, the butterfly in the air passage in the carburetor is in wide-open position. The screw feature of the dash adjustment is so designed that it may be turned several turns from its seat in order to keep a cold engine running without bucking. As soon as the engine starts to warm up, the adjusting screw should

be turned in toward its seat. This operation is gradually continued until the needle valve seats completely. The device is so designed that seating the needle valve does not completely stop the flow of gasoline through the main jet. In many cases it is possible to operate the car with the needle valve seated completely. If the power obtained from the engine is not all that is desired, the needle valve may be backed off about one-quarter to one-half turn. Naturally, the grade of gasoline being used has considerable to do with the amount of opening required, some grades requiring an opening of one-half turn more than other grades.

This feature is a very desirable one when driving in high altitudes, since it is possible to seat the high-speed needle completely, thus giving a leaner mixture. Contrary to popular opinion it is not good gasoline economy to turn the carburetor so low that the engine will barely turn over or develop the power needed. Tests on the road have shown conclusively that the adjustment at which the engine develops the best power is the most economical. These tests have shown that with a mixture as lean as it is possible to have the engine operate on, less miles per gallon were secured than with a proper mixture.

Trouble-Shooting Hints. Check the gasoline tank to see whether the fuel supply has been exhausted. Next, check the feed line to see that fuel flows to the carburetor freely. Finally, make certain that there is fuel in the carburetor. If no fuel feeds to the carburetor, remove the plug and screen *A*, Fig. 65, and clean them. The next thing is to check the secondary venturi *D* to see that it is in the position shown. If the car owner complains of lack of speed, the main jet *E* should be checked to see whether it is clean and free of any particles of dirt which may have tended to clog it. If the customer complains of poor idling and poor slow-speed performance, the compensator *F*, Fig. 66, should be checked to see that it is clean. The idling jet *G* furnishes all of the gasoline for idling, consequently the tube and metering hole must be kept clean and free of dirt. If the customer complains of leaks about the carburetor, the parts should be checked for physical damage and all connections should be tightened.

Surprising as it may seem, there are many owners who are fearful of touching the dash adjustment on their cars. These are

the customers who are likely to complain about the lack of fuel economy. As a matter of fact, they are running with the screw adjustment turned back from its seat as much as a turn or more. The best plan is to take these customers on the road and show them how simple a matter it is to adjust the carburetor and then have them adjust the carburetor until they are thoroughly familiar with it. The characteristic sounds of a properly operating engine, or one which is too rich or one which is too lean, are easily learned by any one if the proper instruction is given.

FORD "V-8" TYPE CARBURETOR

Early Models*

The Ford "V-8" carburetor is of the down-draft type, specially adapted for the Ford "V-8" engine, Fig. 68. The carburetor size is $1\frac{1}{4}$ inches. The carburetor is entirely automatic, and as the adjustments are made at the factory, it is claimed they will remain correctly set unless tampered with.

The two main units are the main metering unit and the auxiliary unit. The main metering unit is composed of a pair of air valves, so arranged that they open downward to admit air in the mixing chamber. On these valves are fingers which actuate a centrally located aspirating tube. As the valves are lowered, they open the aspirating tube. This aspirating tube is attached to a spring loaded hollow stem, with the fuel metering orifice at its upper end, and into this orifice an adjustable tapered metering pin projects.

The auxiliary unit combines a passage for starting, an acceleration pump, and an auxiliary power jet. The lining up of progressively located ports in the starting sleeve with passages in main body controls the operation of the auxiliary unit. The movement of the choke valve rotates the starting sleeve; and as the throttle is opened, the pump plunger and piston move downward.

The correct ratio of air and gas is maintained by the action of the air valves and the metering device. At idling speed the valves are closed, and the metering pin almost closes the orifices in the air valve piston. As the suction increases, it draws the air valve down

*The later type Ford "V-8" Double-Barreled Carburetors are described later in this section.—Ed.

and the metering pin is also lowered, and this causes the enlargement of the metering orifice and thereby allows more gas to pass into the air stream, giving a correct mixture.

For maximum power at any car speed, a richer mixture is obtained by way of a power jet, which supplies extra fuel as long as the throttle is held open. The lower air bleed holes, located in the starting sleeve, control the amount of gasoline drawn through the power jet.

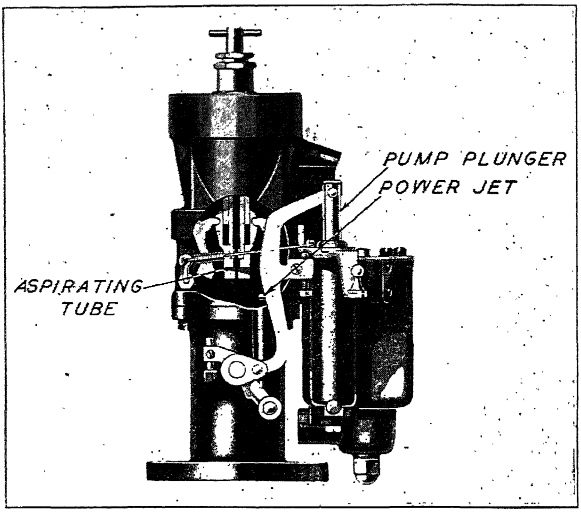


Fig. 68. Ford "V-8" Single-Barrel Carburetor

For quick pick up, a rapid opening of the throttle causes a rapid downward movement of the pump plunger and piston, which in turn forces gasoline up through the hollow stem of the pump plunger into the mixing chamber.

To prevent the gasoline leaving the pump cylinder and returning to the float bowl, a check valve is placed at the bottom.

Generally only one adjustment is required and that for idling speed. When the metering pin is set correctly, the carburetor is also set for maximum engine operation.

With the engine thoroughly warmed up, turn the metering pin adjustment down until the engine operation indicates a lean mixture.

and then open metering adjustment until engine operates smoothly.

Be sure that there are no air leaks in the intake system, or in any attachment operated by the intake vacuum.

MARVEL CARBURETORS

The Marvel carburetor is quite similar in all of its models, irrespective of whether the heat control is applied to the device or not. When the heat control device is applied, the outward form of the carburetor is considerably changed. However, the inner construction and the principles involved in the operation of the carburetor remain very similar. The influence of the heat control will be discussed with reference to the different models.

The distinctive feature of the Marvel air valve is a tongue-like or flapper-like arrangement which is carefully manufactured to fit in the lower part of the air passage just above the high-speed or medium high-speed nozzles, where two of these are used.

Marvel Heat Control. This device is a distinct Marvel design. The principles involved may be explained in a few words. It is exactly the same as though a few drops of liquid were poured on to a hot stove lid. Instant vaporization occurs.

Principles of Marvel Up-Draft Carburetor. This is shown in Fig. 69 and other figures. Three jets are provided within the mixing chamber. These jets provide the required amount of gasoline for the varying speeds. The low-speed jet is located in the venturi, which is a fixed air passage. The high-speed jet is located just under the air valve and an intermediate high-speed jet is just under and back of the high-speed jet. The gasoline jets are of a fixed size, calibrated at the factory to meet the requirements of the engine to which the carburetor is fitted. The air valve, which is located at the lower end, is in the nature of a tongue, carefully designed to fit into the circular form of the carburetor body.

The only adjustment of this carburetor is that of the air-adjusting screw which controls the air-valve spring tension. Earlier models were provided with a gasoline adjusting screw for the low or idle-speed jet. Improvements in later designs do away with having an adjusting needle at this point.

Choker. The choker valve is unique in design in that the lower side of it is weighted. In Fig. 70 the butterfly choker valve with

a weight attached to its lower edge is shown in full view in a position which would correspond to approximately 15 miles per hour car speed. A phantom or dotted line view shows the same butterfly choker valve further opened—a position which would correspond to 30 miles per hour car speed. As the car speed increases and the demand for air increases, the butterfly throttle choker valve is pulled farther and farther open.

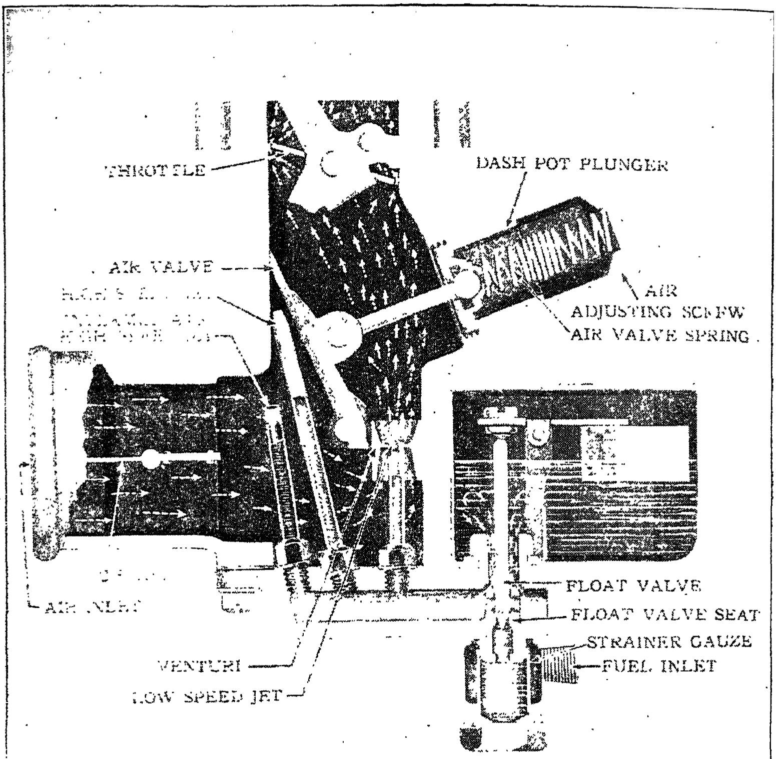


Fig. 69. Parts of a Typical Marvel Carburetor with Idling Action Illustrated

When starting the engine, the choker may be closed by means of the choker control on the dash. The choker is first pulled all the way out and then the throttle is opened about one-quarter, after which the starter button is depressed. When the engine fires, depress the choker part way. If the engine hesitates, pull the choker a bit farther out and then proceed to push it in as rapidly as the engine warms up.

Adjusting the Carburetor. First make certain that the heat control valve on the exhaust manifold is set in a proper position for the season of the year or the climate in which the car is being operated. The next point to inspect is the top of the carburetor fuel bowl where a little lever will be found. See Figs. 73 and 74. This should be set for summer or winter markings, depending upon the season.

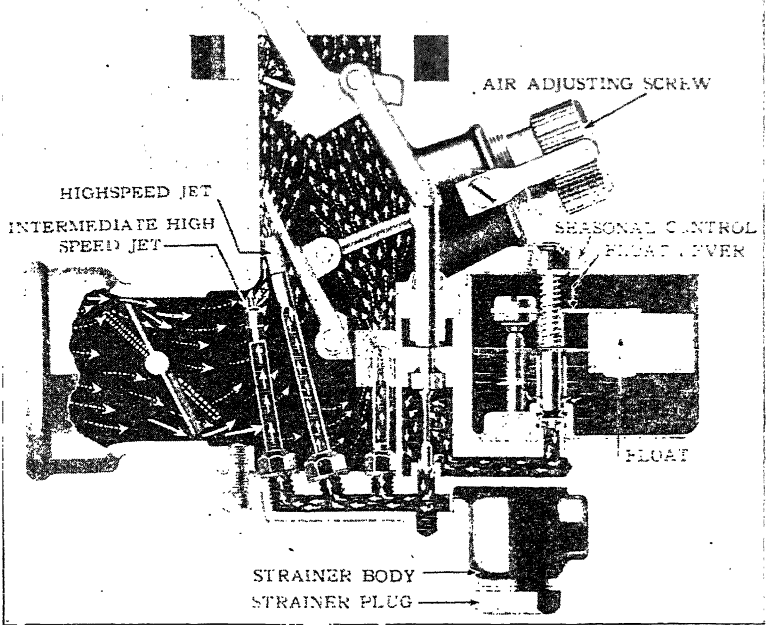


Fig. 70. Automatic Action of Choker Valve Illustrated

Next make certain that the gasoline or fuel passages are clear to the carburetor and that the carburetor screen is not clogged. Check the fuel pump to see that it is supplying a proper amount of fuel; also check the manifold and other connections to see that there are no air leaks. Start the engine and run it until it is thoroughly warm. Check the ignition system to see that it is in good condition. It is useless to attempt to adjust a carburetor to compensate for deficiencies of other systems.

Set the air-adjusting screw of the carburetor so that the end of it is flush with the end of the ratchet spring. Now turn the air-adjusting screw inward a few turns until the engine starts to roll, after which it may be turned out a few notches until the engine falters through leanness. Midway between these two points will be found the proper setting. This is the only adjustment to be made in order to secure proper carburetor performance for all

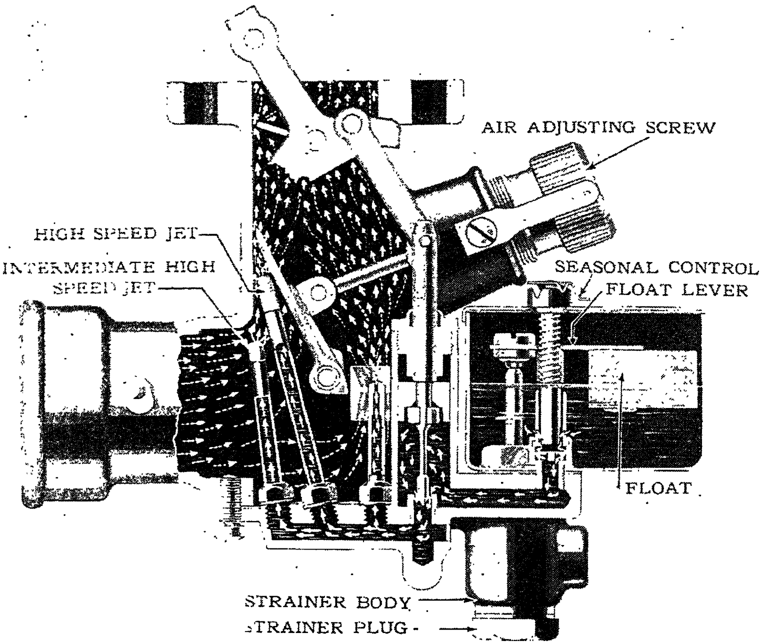


Fig. 71. The Economizer Action—Fuel and Air Are Represented by Arrows

engine speeds and loads. The engine speed at which to proceed with adjusting of the air screw is that approximating 10 miles per hour on the road, then reduce speed to desired idling speed for final check.

Adjusting Idle Screw. It is necessary to check the car on the road in order to prove the setting of the idle adjusting screw which controls the opening of the butterfly throttle valve. This should be set so that the car operates at a speed of at least 5 miles per hour.

Carburetor Operation. The passage of the fuel from the bowl direct to the low speed jet in the venturi is shown in Fig. 69. The adjustment of the air valve to pass more or less air effects the flow through the fixed air passage. The air entering the carburetor comes in past the choker. The carburetor suction on low speed is induced by more pressure on the air-adjusting screw. In this way more or less fuel is caused to flow from the low-speed jet and consequently the low-speed adjustment is secured by means of the air-adjusting screw.

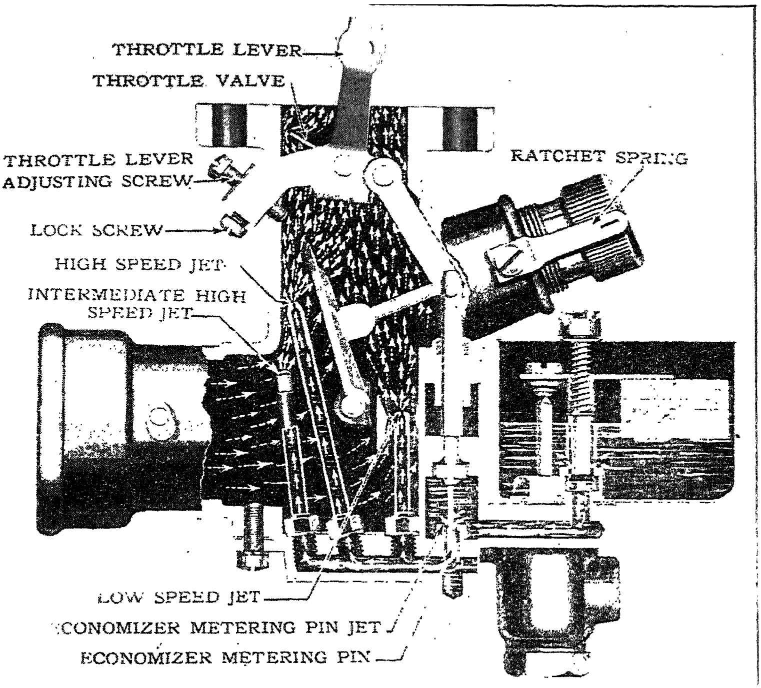


Fig. 72. Economizer Action from 50 Miles per Hour to Wide-Open Throttle

Economizer Action. The economizer action is illustrated in Figs. 71 and 72. The economizer metering pin is attached to the throttle control. See Fig. 68. It will be noticed that the lower end of the economizer pin is provided with an enlarged point. This point being in the economizer metering-pin jet provides a calibrated opening through which the gasoline flowing to any of the jets must

pass. As long as the enlarged portion of the metering pin is within the jet, this holds. This condition obtains for all speeds of the car up to approximately 50 miles per hour. After passing this speed, the throttle being wide open, the metering-pin enlargement is dropped below the calibrated opening with the result that an

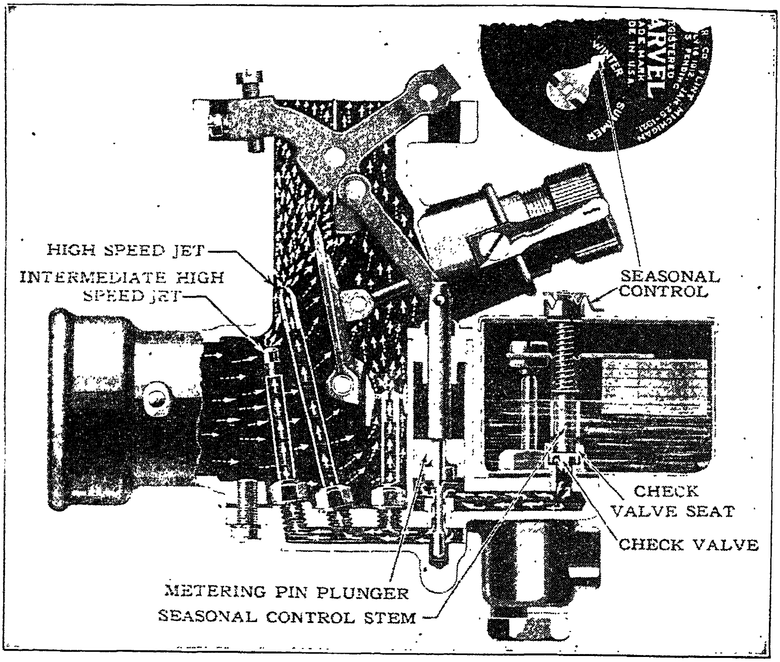


Fig. 73. Winter Setting for Accelerating Device
The insert in the upper right-hand corner shows the dash controls.

additional flow of gasoline is permitted. This is illustrated in Figs. 73 and 74.

When the metering pin has dropped below the metering-pin jet, the amount of gasoline is no longer measured by this jet but is measured by the calibrated opening of the high-speed and intermediate high-speed jets. These are so calibrated as to provide for a proper mixture of air and gasoline for fullest power and best acceleration as would be secured when traveling over the level at

high speeds or up hills or hard going. On the accelerating device there are two settings, for winter and summer. The action of the carburetor when accelerating rapidly with the winter setting is illustrated in Fig. 73. The arrows going into and through the gasoline and air passages indicate the action of the mixture. It will be noted that the air valve is open wide. It will also be noted that the

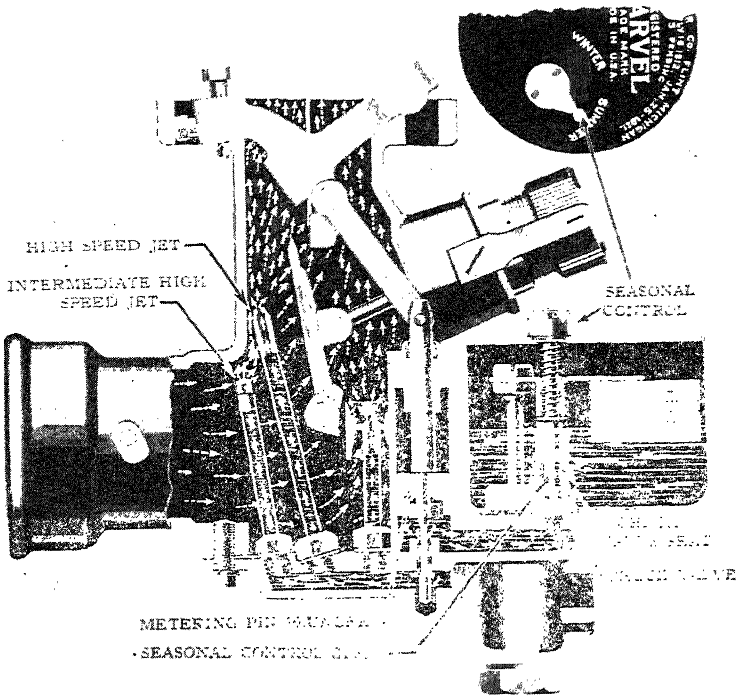


Fig. 74. Summer Setting for Accelerating Device

plunger connected to the throttle lever has moved down and forced the check valve under the seasonal control stem up against its seat so that all gasoline within the passage from the check valve over to and in the accelerating well must be forced ahead of the descending metering-pin plunger and out through the calibrated openings of the high-speed jets. This fuel, of course, is picked up and acts as the required accelerating fuel to mix with the large amount of air entering past the air valve. The seasonal control on the top of

the carburetor bowl in the setting shown is up and away from the check valve so that it can raise against its seat.

With the summer setting which is shown in Fig. 74, the stem of the seasonal control is down on the check valve for summer driving. This prevents the valve from closing. The result is that when the throttle is opened wide for rapid acceleration, the metering pin plunger cannot force all the fuel in one direction, part of it going back into the bowl and a little of it being forced from the high-speed jets. This feature of design, if properly set, results in economy of fuel in the summer months while at the same time the desired acceleration may be secured for driving in colder climates.

Float-Valve Setting. The setting for the float valve is $\frac{11}{32}$ inch from the top edge of the float bowl to the top of the cork float. **The seasonal control should always be set** to "winter" in cold weather and the manifold heat should always be set "hot" for cold weather driving. If the performance of the car is sluggish in the summer months first check the seasonal control and see that it is set to "summer" position. After this, if the performance still remains poor and sluggish, the manifold heat control should be set to "cold" position.

BUICK UP-DRAFT MARVEL CARBURETOR

The Marvel automatic air valve, multiple jet type carburetor is used on Series "50-60" and "90" models. This carburetor employs a single float bowl with twin mixing chambers, air valves, throttles, and heat risers. The throttles are carried in the heat riser between the carburetor body and intake manifold. Four non-adjustable jets are provided in each mixing chamber as follows: The low-speed nozzle is within the venturi. The high-speed and intermediate high-speed jets are just under the automatic air valve and controlled by it, and a submerged-economy jet is in the sump and under the high-speed standpipe.

A single adjustment is provided, which is the air adjustment screw that regulates the tension of the air-valve spring. A plunger within this screw provides resistance, in addition to that of the air valve spring, to aid in acceleration. The float valve is an overhead type which prevents fuel being drained from the bowl when the car is parked with the front end higher than the rear.

The low-speed nozzles and intermediate high-speed standpipes have extensions on their lower ends reaching very close to the bottom of the bowl sump. The bowl is so designed that the economy jets are also located to take fuel from the bottom of the bowl sump. This design thus prevents vapor bubbles from passing through all nozzles and jets. See Fig. 75. For full power requirements, fuel is metered through the low-speed nozzles, high-speed, and intermediate high-speed jets. For part throttle driving range, economy jets are placed between the main fuel supply and the high-speed jets.

The additional fuel required for full power requirements, or wide open throttle operation is supplied by a non-adjustable fuel by-pass valve automatically operated by the carburetor throttle.

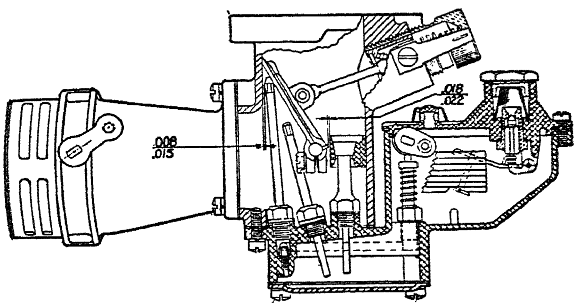


Fig. 75. Buick Carburetor in Cutaway View

This fuel is by-passed through a very short channel to the high-speed standpipes, Fig. 76, entering just above the economy jets. At part throttle driving range, this valve is automatically closed, so that the calibrated nozzles and jets control the amount of fuel being used. When the throttle is fully opened for high speeds, hard pulling, or quick acceleration, this valve opens and supplies additional fuel necessary to obtain the maximum power from the engine.

Adjustment. No change should be made in the carburetor adjustment until after inspection has been made to determine if the trouble is in some other unit. It should be determined that the gasoline lines are clear, that the fuel pump is properly supplying fuel, that there are no leaks at connections between the carburetor and engine, that the ignition system is in proper condition and that there is even compression in all cylinders.

If it is necessary to test adjustment or to make a readjustment, proceed as follows: Turn the air screw so that the end is flush with the end of the ratchet spring bearing against it. With the engine warmed up, adjust the air screw for proper idling. Turn the air screw to the left until the engine hesitates, indicating that the mixture is too lean. Next turn the air screw to the right three or four notches at a time until the engine runs smoothly. Open the throttle a small amount and immediately allow it to snap back to the closed position. If the engine stalls, the air screw should be turned to the right. If it rolls, the air screw should be turned to the left until the

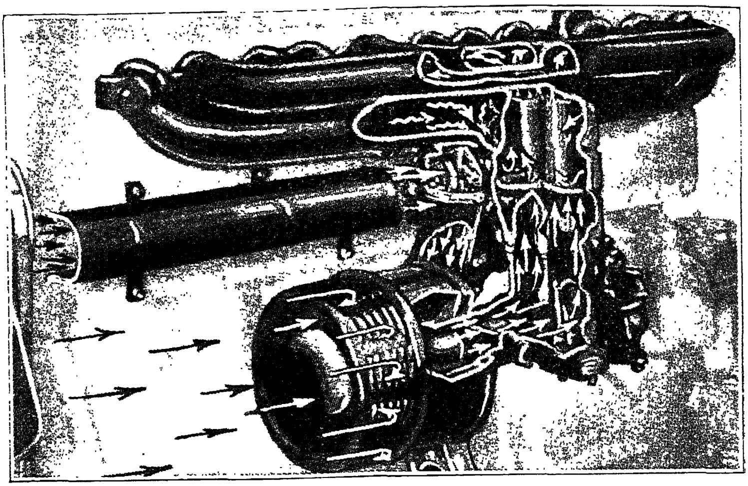


Fig. 76. Buick Carburetor and Heat Control

engine continues to idle smoothly. This brings the carburetor into complete adjustment for the entire range of engine speeds and loads. Except for altitude territory, service abroad, and certain foreign fuels, no change from standard jets should ever be made, as no better power, speed or fuel economy will result thereby.

Adjusting a carburetor, so as to secure just the last bit of fine performance from the engine, is an operation which requires knowledge of the principles of design of the carburetor being adjusted. After that is gained, experience is the best teacher.

If the engine idles too fast with the throttle closed, the latter may be adjusted by means of the throttle lever adjusting screw.

No change is necessary for touring through mountainous country, but for cars operating permanently in territory of 3000 feet elevation or higher, it is advisable to change the carburetor calibration to obtain best performance.

Cold Idle Control. The cold idle control, Fig. 77, consists of a thermostatically operated cam *K* mounted on the carburetor heat riser. This cam serves as the stop for the idle adjusting screw *D*. The function of the cold idle control is to provide a fast idle speed during the warming up period of the engine. This speed increases or decreases as the temperature of the riser changes. The variable

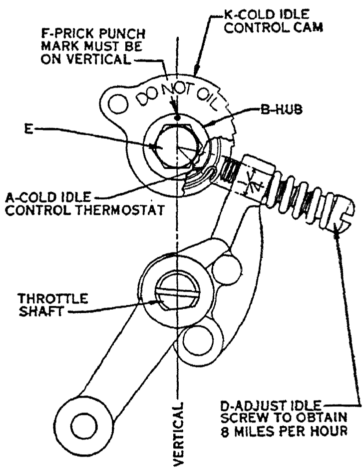


Fig. 77. Cold Idle Control

speed is obtained by using a thermostat *A* which drives the cam *K*. When the riser is cold the thermostat *A* rotates the cam *K* in a clockwise direction, causing its thick side to contact with the idle screw *D*, which speeds up the engine. As the riser warms up, the thermostat is heated and thus revolves the cam *K* in a counter-clockwise direction until the idle screw *D* is contacting with the cam *K*, at its thinnest section, causing the carburetor throttle to close to a normal hot idle speed.

The cold idle control is adjusted and set in the correct position at the factory and with ordinary care should not need any further adjustment. This setting can be checked as follows: Loosen nut *E*

and rotate cam hub *B* in the direction necessary to place the prick punch mark *F* directly above nut *E*. This adjustment may be made regardless of heat riser temperature. A momentary opening of the throttle is necessary to allow the cam *K* to adjust itself for any temperature position. This is because the spring *A* is not capable of rotating cam *K* while the idle adjusting screw is contacting the cam.

Warm up the engine. The idle adjusting screw *D* should now contact the cam *K* on its thin portion and within the $\frac{1}{4}$-inch limit adjoining the first raised section of the cam. See Fig. 77. If the idle adjusting screw does not contact within the limit shown, the cam hub may be rotated slightly in order to bring $\frac{1}{4}$-inch section under the idle screw. If it is necessary to rotate the hub enough to move the center punch mark *F* more than 5 degrees away from its normal top position, a complete new cam assembly should be installed. All moving parts of the cam assembly should operate freely and no oil should ever be used on them.

Buick Carburetor Automatic Choke. The Delco-Remy automatic choke is attached to the front side of the carburetor riser. It takes the place of the conventional hand choke of the engine under all weather and temperature conditions. It gives immediate performance and is fully automatic.

The operation of the Delco-Remy automatic choke is controlled by the variation of the three fundamentals in present carburetion systems, namely: 1. Hot spot or carburetor riser temperatures; 2. Manifold vacuum; and 3. Carburetor air inlet velocities. The thermostatic spiral spring in the automatic choke has one end secured to the shaft, which controls an offset choker fly in the carburetor air horn by means of linkage. The other end of the thermostatic spring is connected to a spring loaded bellows.

This thermostatic spring has the property to increase its tension, by further winding itself up, as the temperature decreases and vice versa. Due to this characteristic, when the engine cools down, the thermostatic spring increases the tension on the choker fly and chokes the carburetor in proportion to temperatures. When starting a cold engine, the choker fly should be held closed with the correct tension until enough fuel has been lifted in the intake system to produce initial firing of the engine. As soon as the engine fires, the vacuum in the manifold rises rapidly and vaporizes a certain amount of fuel,

which calls for a leaner mixture. The force of this vacuum is used to collapse the spring loaded bellows. This rotates the thermostatic spring end in a clockwise direction and decreases the initial tension on the choker fly of the carburetor.

The amount of decrease in tension is regulated by the stroke variation of the bellows. This variation is obtained by an adjustable (cam shaped) stop, which gives the correct tension for proper choker fly position under all part throttle engine loads and speeds. The

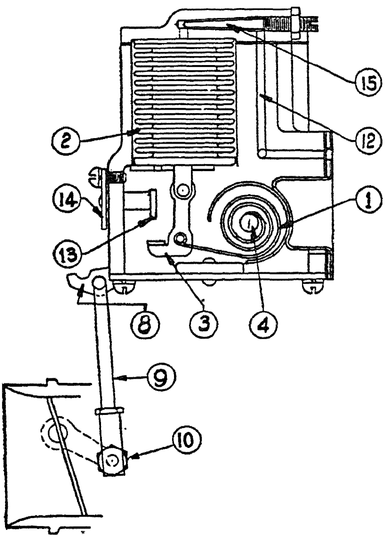


Fig. 78. Buick-Delco-Remy Automatic Choke

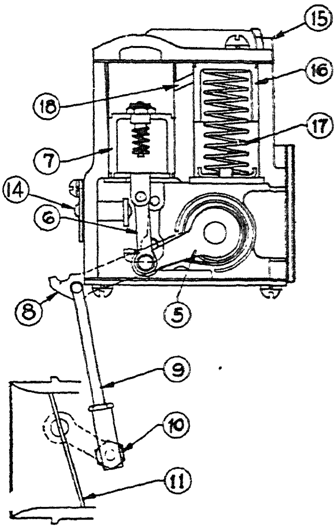


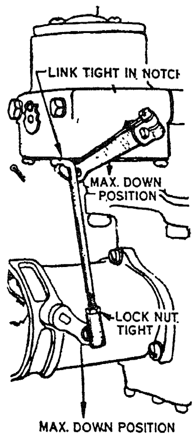
Fig. 79. Another Sectioned View of the Buick Choke

spring tension will regulate itself according to temperature, and decrease as the engine warms up until the automatic choke is completely out of operation. The time required for the choker fly to travel from the choking position into the part throttle position is controlled by a metering pin, which regulates or meters the vacuum action on the bellows.

Service and Adjustment. The Delco-Remy automatic choke parts and service are available through United Motors Service branches and their authorized stations. This choke unit should not be disassembled except by the above named organization. The units are

properly calibrated at the factory, and it should not be necessary to make any adjustments in the field. However, if trouble arises, the following procedure is recommended.

First remove the link *9*, Figs. 78, 79, and 80, from automatic choke lever *8*. Hold down both levers *8* and *10* as far as they will go. Check the length of link *9*. Adjust to fit into the notch of the automatic choke lever *8*. Reinstall link *9* in lever *8*. Next check the choker fly action by moving the automatic choke lever *8* up and down. Moving parts must work freely and the lever must always come back to its original position. (Original position, meaning position in which levers are found, due to choke temperature at the time of checking.) Make sure all moving parts and joints are dry and free from oil of any kind. Never oil any part of the choke mechanism.



Link Adjustment

Engine Does Not Start. If the engine fails to start after several trials, with the choker fly in the full choke position, probably the engine is flooded. If flooded, open the choker fly by hand, by pulling up on lever *8*. The engine can probably then be started and run sufficient to eliminate flooded condition.

Stop the engine and let it cool down until the choker fly is again in full choke position. Start the engine again and notice if the choke lever travels slowly up to its part throttle position. If not, the vacuum is failing to release the choke, therefore, check for vacuum leaks, vacuum channels plugged, or incorrect bellows metering-pin timing.

Bellows Metering-Pin Timing. The bellows are properly timed at the factory and before making new adjustments, make certain that all vacuum leaks and channel obstructions are eliminated. If timing is necessary, proceed as follows: Allow the engine to cool until the choker fly returns to closed position. Start the engine and check the time required for the automatic choke lever to travel up to part throttle or upper position. It should take 12 to 15 seconds to complete this movement. Time can be increased or decreased by adjusting the bellows metering pin *15* in or out.

Caution. See that the metering pin lock nut is securely tightened after adjustment.

Idling. Idling speeds must be correct for proper engine starts in summer as well as in winter. Idle should be set for 7 to 8 miles per hour in high gear with warm engine. (See Cold Idle Control.)

Part Throttle. The part throttle setting of the choke is indicated by adjusting the disc *14*. This is set at the factory in the center notch between rich and lean and should not be changed.

Acceleration. With the engine running and the automatic choke lever *8* in the upper or off position, accelerate the engine suddenly. The lever *8* should drop immediately and momentarily, then return to its original position. The intensity of this action should decrease until it practically ceases to function as the engine becomes hot.

Cold Weather Starting. In cold weather, the clutch should be disengaged by depressing the clutch pedal before depressing the accelerator pedal to remove the drag caused by cold oil in the transmission and insure a higher cranking speed. Turn on the ignition switch. Depress the clutch pedal (in cold weather). Depress the accelerator pedal.

When the engine first fires, keep the foot on the accelerator pedal long enough to make sure that the engine will keep running. As a further assistance in cold weather starting, it may be desirable to use a good grade of high-test gasoline. In districts where the climate provides lengthy periods of sub-zero weather, it may be advisable to remove the heat valve thermostat shutter, by disconnecting the shutter operating link at the throttle lever and removing the retaining washer and spring. This will leave only the open thermostat cover which will allow cold air to blow on the thermostat at all times, maintaining a high tension on the heat valve, thereby giving a higher mixture temperature. With the return of warm weather, the shutter and parts should be reinstalled, as a cold thermostat will give mixture temperatures too high for normal weather, resulting in loss of performance.

Heat Control. The carburetor and manifolds have been designed to utilize the exhaust gases of the engine to insure complete vaporization and a consequent minimum consumption of fuel. A double-walled twin riser, Fig. 81, is placed between the carburetor and the

intake manifold, connecting to the exhaust manifold on one side and held in place by four studs. The gases, passing to the riser jacket through the upper opening and returning through the lower opening to the exhaust manifold, are automatically controlled by a thermostatically operated damper valve located in the exhaust manifold outlet.

The damper valve applies the greatest amount of heat to the riser, when in a closed or horizontal position, Fig. 81, decreasing the amount as it moves to the open or vertical position. The damper valve fly is offset, or longer on one side of the valve shaft than the other, which allows the exhaust gas pressure to force open the valve when free to move. The valve is so arranged that at no time is all

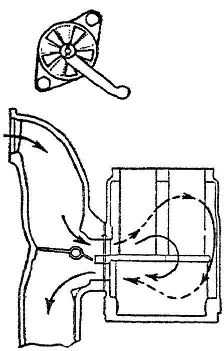


Fig. 81. Heat On
Damper Closed
Shutter Closed

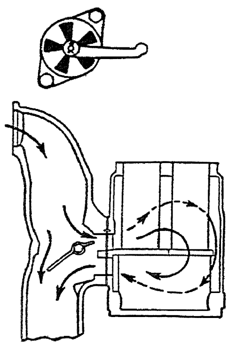


Fig. 82. Medium
Damper Partially Closed
Shutter Open

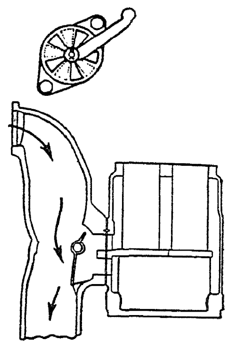


Fig. 82A. Heat Off
Damper Open
Shutter Closed

the heat shut off from the riser. A sufficient amount of heat is allowed to pass into the riser to insure proper vaporization of the fuel.

The thermostat controlling the damper valve consists of a bimetal strip wound so as to form a coil around the damper valve shaft, with the inner end inserted in a slot in the end of the damper valve shaft. The outer end of the coil is hooked around an anchor stud on the damper valve cover.

The setting of the thermostat, Fig. 82, should be approximately one-half turn windup at normal room temperature, causing tension to be applied to the damper valve, holding it in a horizontal or "heat on" position and forcing exhaust gases through the riser. Heat conducted by the damper valve shaft to the thermostat causes

it to unwind, reducing the tension on the damper valve which allows the valve to be forced, by the exhaust gas pressure, toward the vertical or "open" position shown in Fig. 82A.

As more temperature is required at part throttle to insure best performance and economy, it is necessary to cool the thermostat and cause it to wind up. This tends to close the damper valve, and applies more heat to the riser. This is accomplished by a cover, which completely encases the thermostat, having a shutter operated by the throttle lever through a link, which at intermediate car speed or part throttle, is opened in proportion to the throttle movement from approximately 30 to 70 miles per hour. Air from the fan, directed by an air tunnel fastened to the engine, passes through the opening of the shutter and cools the thermostat, which automatically increases the mixture temperature.

For open throttle running and hill climbing, the shutter is held closed, which keeps the heat around the thermostat and causes it to unwind. This allows the damper valve to open, and reduces the mixture temperature.

Marvel Manual Heat Control. The carburetor and manifolds have been designed to utilize the exhaust gases of the engine to insure complete vaporization and a consequent minimum consumption of fuel. This is accomplished by an exhaust jacket in a double-walled riser casting, placed between the carburetor and intake manifold. This riser casting is also connected with the exhaust manifold in such a manner that the exhaust gases pass through a small jacketed section of the intake manifold, entering an opening at the top and back of the riser, passing down between the jacket walls of the riser, and then out to the main exhaust. The amount of heat thus furnished to the riser is controlled by a damper valve in the main exhaust.

This damper valve in the main exhaust is connected to the throttle lever of the carburetor by connecting a rod in such a manner that the greatest amount of heat is had in the jackets of the riser when the throttle is only partly opened, as in idling and at low speeds, and a decreasing amount as the throttle is opened farther for higher speeds. By means of a season adjusting stud on the heat-control lever on the damper-valve shaft, this automatic action of the heat valve may be varied to suit weather and driving conditions.

The damper valve is in the main exhaust at the rear end of the engine and is assembled in the exhaust-manifold casting. On the front side of this damper-valve cover will be noticed a boss, acting as a locating stop for the damper-valve lever. This stop indicates the closed position of the damper valve and is to be used in assembling the connecting rod to the carburetor. The normal position of the damper valve is against this stop when the season adjusting stud on the heat-control lever is set at "hot" and the throttle is in closed position.

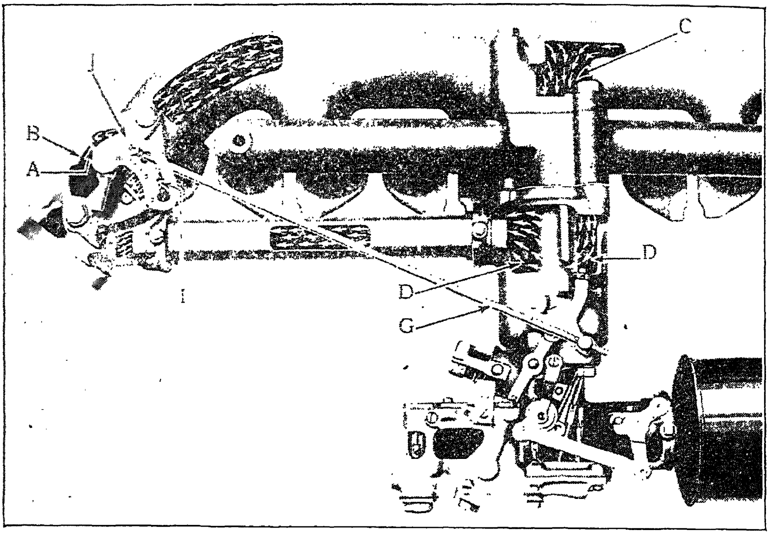


Fig. 83. Marvel Control in "Hot" Position
The valve *A* is closed to deflect heat through the riser.

An adjustment for seasonal control of heat is provided on the damper-valve lever *I*, Fig. 83, whereby the amount of exhaust heat deflected by the damper to the riser jackets may be decreased by moving the damper adjusting stud *J* from the hook-up hole in the damper lever marked "hot" to the hook-up hole marked "medium" or to the hook-up hole marked "cold," thus initially opening the damper valve at closed throttle positions and greatly reducing the heat application.

Gases from the main exhaust pass through a small jacket on the intake manifold and enter at an opening at the top and back

of the riser, Fig. 83, and then pass down through the riser jackets, returning to the exhaust pipe below the valve *A*. It will be noted that valve *A* is connected by means of connecting rod *G* to the throttle stop lever. As the throttle is opened, valve *A* is also opened, due to this interconnection. Thus the volume of heat through the heat jackets of the riser will be lessened as the engine speed increases, depending upon the position of the season adjusting stud *J* in the damper lever *F*.

In Fig. 83, showing "hot" heat position, note the shape of the exhaust manifold land *B*, adjacent to the edge of the valve in closed position. At closed throttle, valve *A* is at the extreme right-side edge of the land *B* in the exhaust manifold. As the throttle is opened, valve *A* rotates counterclockwise so that its edge passes across this land *B* but the valve itself does not open until it clears the land *B*, thus insuring maximum heat circulation.

Servicing Model "T"* Marvel Carburetor. This carburetor is equipped with a heat control which varies with different devices furnished for different makes of cars the principles upon which they operate being quite similar. When servicing the carburetor, make a careful inspection of the heat-control device. Note whether the main damper valve in the exhaust is properly hooked up so that, when the throttle is closed against it and the heat control is set with all the heat on, the main damper valve comes to full-closed position.

Preliminary Adjustment. First set the spark retarded and then adjust the idle speed by turning the air screw *A*, Fig. 86. Screw this out until the engine falters, then turn it in the opposite direction a few notches at a time until the engine runs smoothly. Have the engine thoroughly warmed up when making this adjustment. Also make sure that the heat control lever on the instrument board is set in a medium position for summer and with all heat on in the winter. If the air screw is turned in too far, a rolling effect will be noted in the engine and this indicates too rich a mixture. Adjust the air screw *A* until an even operation of the engine is secured.

Idle Adjustment. This is made by adjusting the throttle-adjusting screw *B*. First loosen the lock screw which holds *B* in the lever and then turn the adjusting screw to what would seem

*The Model "T" is the Buick. These instructions are also applicable to the Nash and Hudson.

to be the approximate engine speed for about 5 to 6 miles per hour. Test the car on a level stretch of road to see whether an even operation is secured at 5 miles per hour, adjusting the screw as needs indicate. In case the engine falters or drops a cylinder and the fault is not in the ignition, it may be necessary to set the speed up a bit. This is especially true in cars which have seen considerable

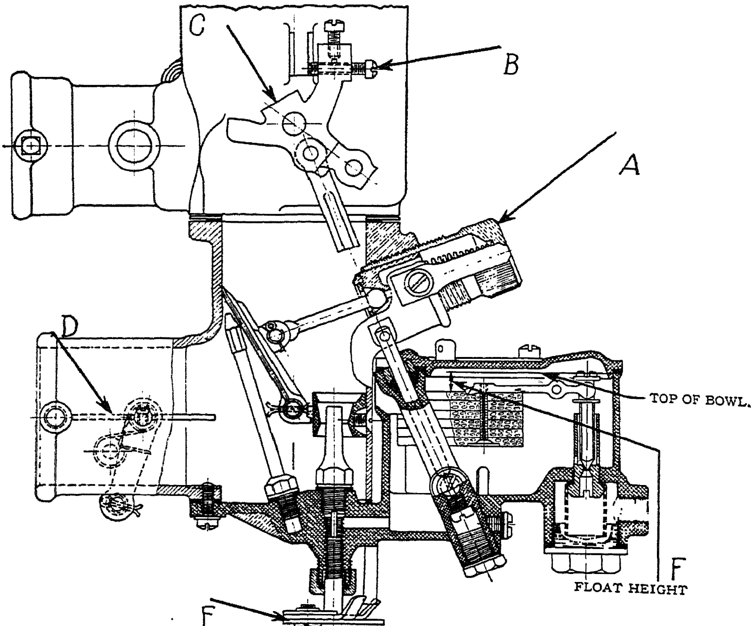


Fig. 86. Service Drawing of Model "T" Marvel
This covers many carburetors fitted to Buick, Nash, and Hudson Cars.

mileage, since the vibration of the car may have worn the engine and carburetor parts to the point where they are no longer as efficient as when new.

Final Floor Adjustment. Open up the throttle *C* quickly and then close it quickly. Note the action of the engine when it returns to idle speed. If it stops or tends to stop, it will be necessary to give the air screw a few more notches inward. A final setting of the air screw *A* will usually be found approximately even with the end of the ratchet spring bearing against it.

Choker Valve Adjustment. The choker valve D, Fig. 86, is a butterfly valve in the main air intake. Inspect the choker valve to see that it closes completely when the choke is worked. If it does not, adjust the control so that it will close completely, otherwise hard starting will be encountered, especially in cold weather with a cold engine. Make a final inspection to see that it opens fully to the position shown in the dotted line at D and see that the choker valve is tight on its shaft.

Gasoline Level. The gasoline level is controlled by the float mechanism, the float itself being of cork construction. Inspect the float, in case of trouble, to see whether it is in good condition. If it is not, it should be replaced with a new one. The dimensions for the float height are as follows. In the case of the die-cast bowl, measure $\frac{19}{64}$ inch from the top of the bowl to the top of the float at the point indicated by the arrow F. The dimensions in the case of the cast-brass bowl carburetor is $\frac{9}{16}$ inch.

Needle-Valve Gasoline Adjustment. Some of the later Marvel Model "T" carburetors are not equipped with a gasoline needle adjustment. Those which have this adjustment are provided with a notched device which is to be set with the notch below the indicator post, above the needle head. This should be done before adjusting the air screw. The real adjustment of the carburetor is secured by means of the air-valve screw, not by the lower needle adjustment.

Servicing Model "A" Marvel Carburetor. *Preliminary Adjustment.* Preliminary idle adjustment is secured by adjusting the brass sleeve B, Fig. 87. This is the air screw and by turning it outward a few notches at a time, it will be noted that the engine starts to slow down and falter. After this is noted, proceed to adjust further by turning the air-screw sleeve B inward a few notches at a time until a smooth and even operation of the engine is secured. As in all cases of carburetor adjustment, it is absolutely necessary to have the engine thoroughly warmed up before proceeding with this adjustment. If the adjustment is screwed in too far, the engine will start to roll and give other signs of being too rich. When the best idle speed with this adjustment is secured, it should be left at this point.

Idle-Speed Adjustment. The idle adjusting screw D is made so

that the car, on a level road with the spark in full advanced position, idles at approximately 5 miles per hour. This screw controls the opening of the butterfly throttle. The lock screw underneath the screw *D* is loosened while turning the screw *D* in order to secure proper idle adjustment, after which the lock screw is reset so as to hold the adjustment.

Final Adjustment. When making a final check for proper adjustment, the procedure is one of quickly opening the throttle. This

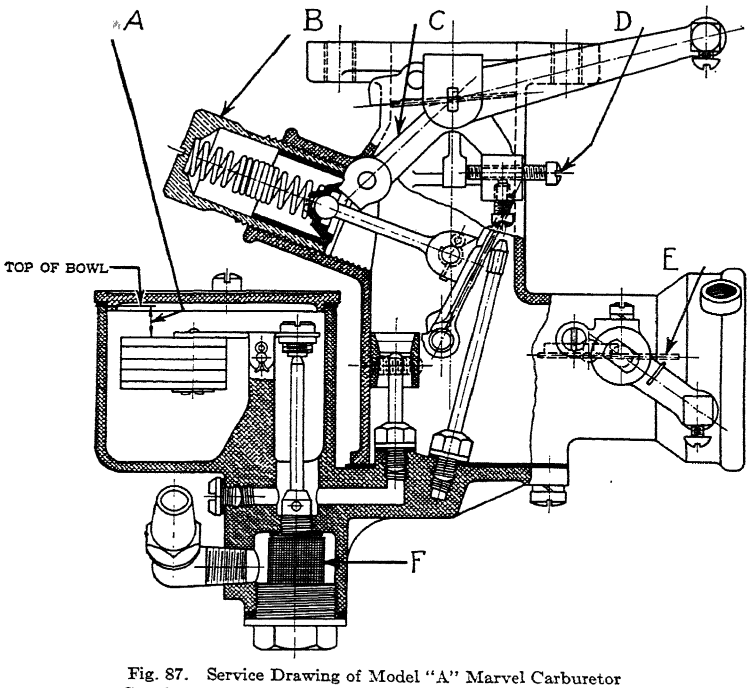


Fig. 87. Service Drawing of Model "A" Marvel Carburetor
Supplied for a large list of popular four- and six-cylinder cars.

is done by grasping the throttle valve control *C* near the carburetor. If the engine falters and tends to stop, the air screw *B* should be turned in a few more notches. It will be found that the final setting of the air screw will be approximately even with the end of the ratchet spring and ratchets on it to prevent the air screw from coming out of adjustment when the proper adjustment has been secured.

Adjusting Float Height. If flooding occurs or if for any other reason it appears evident that the float height and the gasoline level within the float chamber are not correct, the gasoline level should be checked. The correct setting for the float is $\frac{11}{32}$ inch from the top of the bowl to the top of the float with the float valve in its seat. Measure as indicated at *A* in Fig. 87. When inspecting the float, if there is evidence of the failure of the float or if it seems loggy, it should be replaced with a new one and then the dimensions given should be secured.

Choker Valve Adjustment. Much trouble oftentimes is encountered in carburetor adjustments which may be traced to an ineffective choker valve. This is not usually the fault of the carburetor but may be due to faulty operation of the choker-valve operating mechanism. In some cases dirt, dust, or rust prevents the proper operation of the control-valve mechanism. Two things are essential. The first is that when the choker is pulled, the butterfly valve must close fully. The second is that when the choker is pushed in, the choker valve must open fully, as shown by the dotted lines indicated by the arrow *E* in Fig. 87.

Clogged Carburetor. A clogged carburetor may be due to dirt working through the gasoline feed lines and stopping up the screen, shown by the arrow at *F*. All that is necessary to open it up is to remove the plug at the bottom and thus drop out the screen strainer, after which it may be cleaned and replaced.

Cleaning Carburetor. In some cases where gummy substances or other dirt have become lodged in the carburetor, it is necessary to completely disassemble it in order to get at the trouble and remove it. When this is found to be necessary, extreme care should be used in removing the nozzles and taking down other parts. While taking them down, inspect them for any evidence of wear. If the throttle shaft has worn badly, it should be replaced with a new one. In the case of the nozzles, use extreme care to see that they are not enlarged while being cleaned. When reassembling, be very careful to use all of the gaskets in proper position and lock all the parts down securely. Do not attempt to remove the complicated parts of a carburetor without proper equipment. In many cases this is special equipment, which may be secured only from the manufacturer of the carburetor.

PLYMOUTH CARBURETOR

Certain models of the Chrysler and DeSoto cars, as well as of the Plymouth, have used this same carburetor. It is of plain tube down-draft type, Figs. 91 and 92, with fixed jets which cover all speed ranges except the idle range which is controlled with an adjusting needle. The carburetor is equipped with an adjustable accelerating pump and a fast idle device for preventing stalling with a cold

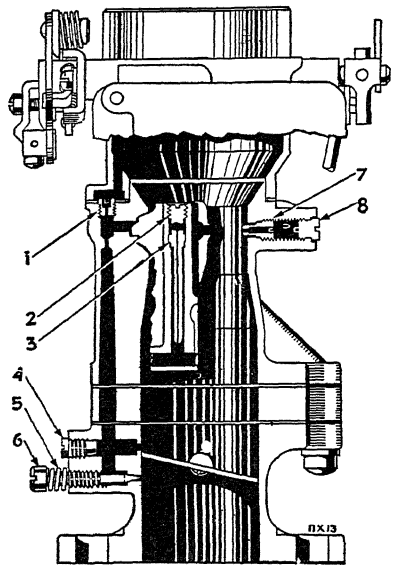


Fig. 91. Front Cross-Section of Plymouth-Chrysler Carburetor

Tube
Adj
-Pump Jet. 8—Pump Jet Plug.

engine. For high altitudes (3000 feet and above) 5 per cent and 10 per cent leaner jets are available from the carburetor manufacturers.

Idle Adjustment. The idle adjusting screw *6*, Fig. 91, controls the fuel mixture for closed throttle running. The idle adjustment operates on an emulsion of fuel and air and therefore turning the adjusting screw clockwise gives a leaner mixture and anti-clockwise a richer mixture.

Note. Before attempting any carburetor adjustments, it is important that the breaker points and spark plugs be properly set,

the ignition timing be correct, and the valve tappets have the proper clearance. Before setting the idle adjustment, the engine must be thoroughly warmed up to its normal operating temperature. With the throttle closed, and the choke in the "off" position so that the fast idle cam is thrown out of operation, turn the idle adjusting screw *6*, "in" until the engine starts to lag or run irregularly. Next turn the idle adjusting screw "out" slowly until the engine begins to roll. Next turn the adjusting screw "in" very slowly to a position

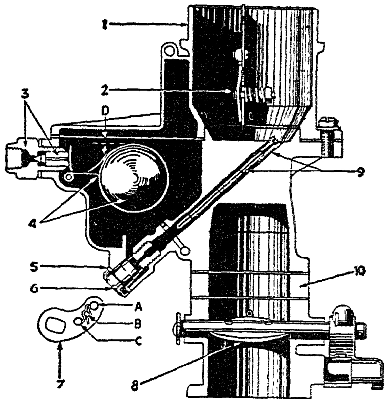


Fig. 92. Side Cross Section of Plymouth-Chrysler Carburetor

A—Accelerating Pump Winter Setting (Outer Hole, Long Stroke). B—Accelerating Pump Intermediate Setting (Center Hole). C—Accelerating Pump Summer Setting (Inner Hole, Short Stroke). D—$\frac{1}{16}$" (1.58 mm.)

1—Air Horn Assembly. 2—Choker Valve Assembly. 3—Float Needle and Seat Assembly. 4—Float and Lever Assembly. 5—Main Metering Screw Gasket. 6—Main Metering Screw. 7—Accelerating Pump Lever. 8—Throttle Valve. 9—Main Vent Tube and Plug Assembly. 10—Body Flange Gasket (Insulator).

between the first and second locations of the adjusting screw. When the proper idle adjustment is reached the engine should run smoothly.

After setting the idle adjustment it may be necessary to readjust the throttle stop screw for the proper idling speed. If a satisfactory idling adjustment cannot be obtained, it may be due to dirt in the idling passages of the carburetor or an engine tune up may be necessary. To clean the idle passages remove the idle needle valve and the idle hole plug. Clean all passages by blowing them out with compressed air. See that the idle orifice tube *3* is clear and that it seats tightly in the carburetor body. Do not use metal or wire in cleaning jets.

Accelerating Pump. In order to provide the additional gasoline required for rapid acceleration, the carburetor is equipped with a pump which supplies an extra charge of fuel momentarily when the throttle is opened quickly. Three positions are provided on the accelerator pump lever in order to give a greater or less discharge of gasoline, depending upon climatic conditions.

For extremely warm weather or for high altitudes (above 3000 feet) the accelerating pump link should be placed in the hole *C*, Fig. 92, in the accelerating pump lever *7*, which is closest to the pump lever shaft. This gives the shortest stroke of the accelerating pump. For normal summer driving, the pump link should be in the middle hole *B*, in the lever. For extremely cold weather operation, the pump link should be in the pump lever hole *A*, which is farthest from the shaft.

Fuel Level. The fuel level in the float chamber is controlled by the position of the float. The top of the float is set 1/16 inch, dimension *D*, Fig. 92, below the surface of the float chamber (without gasket) with the engine idling. It should not be necessary to disturb this adjustment unless the float or the float arm has become damaged by rough handling. If it is necessary to correct the float level, it may be done by bending the float arm near where the arm is fastened to the float.

Fast Idle. The carburetor throttle is mechanically connected with the choke so that if the choke is more than half "on" the throttle will be opened slightly to prevent stalling when starting and warming up a cold engine. With the choke in its fully closed position, the throttle stop screw will rest on the high point of the fast idle cam.

Manifold Heat Control. The exhaust manifold on the DeLuxe "PE" Model is equipped with an automatic heat control, Fig. 93, which regulates the amount of heat by-passed around the inlet manifold heater body. The operation of the heat control on the DeLuxe "PE" Model is fully automatic and no adjustments are required. The heater valve plate *9*, valve plate shaft, and bushings are made of special metals which will not corrode, thereby eliminating the possibility of the valve sticking. An occasional check should be made to insure that the valve is free and is not restricted in its operation.

When installing a new thermostat, it should be placed on the

heat control shaft in the position illustrated at *A*, Fig. 93, and then turned 200 degrees and the end of the thermostat *1* placed under the elbow *3*. If the thermostat installation is correctly made, the heat control counterweight arm *4* will be back against its stop *2*, as shown in the illustration, when the manifold is cool.

The "PF" Model is equipped with a manually adjusted heat

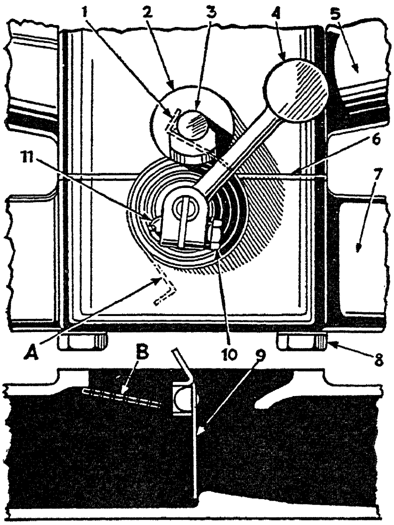


Fig. 93. Automatic Manifold Heat Control Valve and Thermostat (DeLuxe, PE Model) 1—Thermostat. 2—Manifold Heat Control Valve Stop. 3—Intake Manifold Drain Tube Elbow. 4—Manifold Heat Control Valve Counterweight. 5—Manifold Assembly. 6—Intake to Exhaust Manifold Gasket. 7—Manifold Assembly. 8—Intake to Exhaust Manifold Screw. 9—Manifold Heat Control Valve Plate. 10—Manifold Heat Control Valve Counterweight Bolt Nut. 11—Manifold Heat Control Valve Counterweight Bolt.

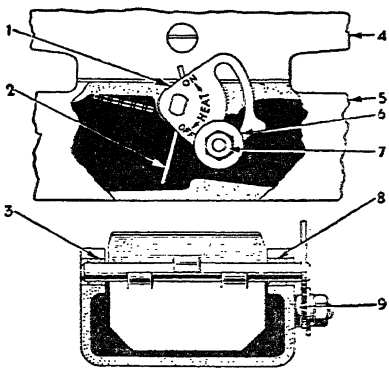


Fig. 93A. Seasonal Manifold Heat Control (PF Model) 1—Heat Control Valve Shaft and Adjusting Plate On Position. 2—Heat Control Valve Shaft Adjusting Plate. 3—Heat Control Valve Shaft Bushing. 4—Intake Manifold. 5—Exhaust Manifold. 6—Heat Control Valve Adjusting Plate Washer. 7—Heat Control Valve Adjusting Plate Stud Nut. 8—Heat Control Valve Shaft Bushing. 9—Heat Control Valve Adjusting Plate Spacer.

control, Fig. 93A. For cold weather operation, the stud nut *7*, on the adjusting plate *1*, located on the exhaust manifold, should be loosened and the plate turned in the direction of the arrow, Fig. 93A to the "on" position. This will place the word "off" under the lock nut. The nut should then be tightened. For high speed driving conditions, the manifold heat control should always be set in the "off" position.

Exhaust Pipe, Muffler, and Tail Pipe. The exhaust pipe,

muffler, and tail pipe are carried on flexible rubber insulated supports to carry out the floating power principle of completely flexible mountings, and to prevent transmission of engine noises to the frame and body.

Therefore, when any parts of the exhaust system are removed, for any reason, upon assembling, the exhaust pipe flange should be attached to the manifold first, and then the rear tail pipe support should be tightened. The front tail pipe support bracket, which is adjustable, should then be tightened in a position so that no strain or tension will be placed upon the exhaust system.

JOHNSON CARBURETOR

Servicing Johnson Model "H" Carburetor. The auxiliary air valve *1*, Fig. 96, is controlled entirely by the specially calibrated steel spring shown under it. This spring is not subject to change and if it should become worn or damaged, it is necessary that it be replaced with a new one, for the particular model being serviced. It will be noticed that the outer end of the air valve *1* is hinged, while the inner end is attached to a dasher or stabilizer rod *8*. This rod has the dasher on its lower end. When servicing this carburetor, be very careful not to damage the rod *8* in any way. If it is not entirely free in action, inspection should be made to find the cause of the trouble. If it is binding at points where it passes through the carburetor body, the air valve action will be interfered with and this will put the entire carburetor out of adjustment.

Idle Adjustment. The screw *2* is the idle adjustment and is used to regulate the gasoline mixture for low speeds, say up to 10 miles per hour. In adjusting the carburetor, this engine speed should not be exceeded. If after screw *2* has been adjusted the engine continues to idle too fast or does not idle fast enough, the throttle-valve adjusting screw should be set.

Choker. The choker, shown at *3*, must lock the air valve closed when the choker button is pulled from the dash. Make a careful inspection of it when servicing the carburetor to see that it locks the air valve closed and at the same time allows the lever to return to the normal position when the choker button is in. This is very important. The lever should swing free.

Economizer. The economizer, shown at *4* in Fig. 96, determines

the quality of the mixture throughout the throttle range by the admission of a calibrated air stream to the main jet. This device is operated in connection with the throttle.

Reatomizing Holes. The reatomizing holes are shown at 5 in

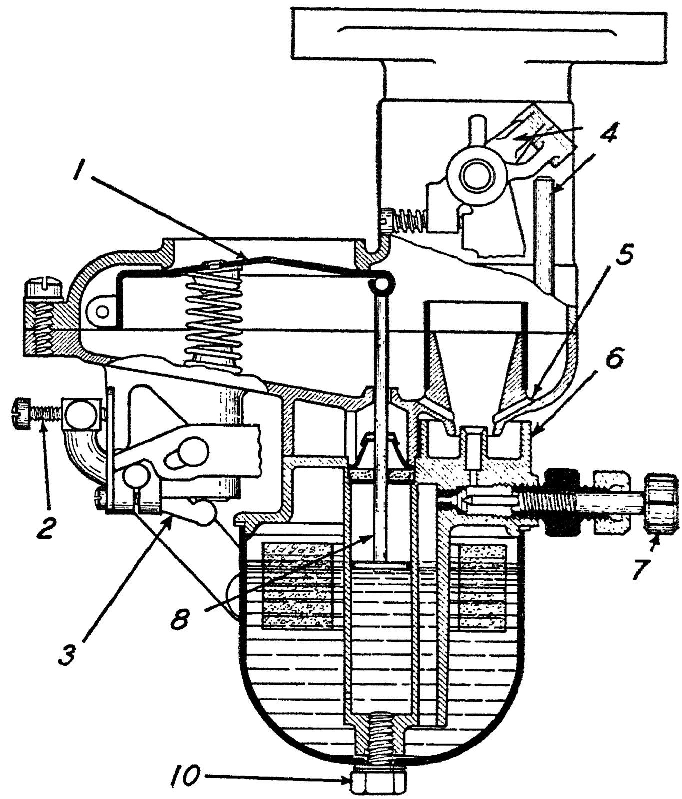


Fig. 96. Service Drawing of Johnson Model "H" Carburetor

Fig. 96. It will be noted that the venturi tube stands within the carburetor body in such position that a small well is formed around it. Any fuel which strikes the throttle or passes into the mixing chamber and is not fully vaporized so that it finally drops back into the carburetor finds its way into this well and through these holes into the primary air stream where it is picked up and reatomized

or vaporized and carried back into the intake manifold in such condition that it may be burned.

Primary Air. The primary air which is used to pick up the fuel from the main nozzle in the venturi enters around the rim of the cup marked *6*. From this point it travels downward around the lower edge of the venturi and then upward through the venturi where it picks up the gasoline from the main nozzle.

High-Speed Adjustment. The high-speed adjustment nozzle, shown at *7* in Fig. 96, is used to regulate the amount of gasoline throughout the entire driving range above the 10-mile per hour, which is controlled by the idle-adjusting screw. In order to secure an adjustment of this screw, it should be turned "in" to make the adjustment lean and "out" to enrich it. By studying Fig. 96 it will be seen that when the screw *7* is turned in, it closes off or calibrates the opening more closely. As it is turned out, more gas is permitted to flow. The carburetor is so designed that an extreme amount of gasoline cannot be drawn through the calibrated opening even though the needle be opened an unwarranted amount. In the case of very high test fuel, the needle should be readjusted in order to secure economy. The normal setting for the high-speed adjustment is approximately twelve notches out or open.

Cleaning Carburetor. It is recommended that every 3,000 miles the screw marked *10* be removed for cleaning the carburetor. This will allow the gasoline bowl to be removed and the strainer housing and strainer may be removed for cleaning. In case the strainer has become damaged or is not effective, dirt may have worked into the carburetor and stopped up the drilled passages. In such cases it will be necessary to remove the carburetor and completely disassemble so as to get at these small openings and clean them. Be very careful not to enlarge the openings when cleaning them as this will destroy the effectiveness of the device.

WINFIELD CARBURETOR

The Winfield carburetor is of the plain-tube two-stage type with fixed sizes for all gasoline orifices and air passages. The delivery of the correct amount of gas for any engine speed or engine load is controlled and governed by the velocity of the air stream and the corresponding vacuum. For this reason a Winfield is free from all

moving mechanical parts such as cams, valves, pumps, and other metering devices. The throttle is the only moving part aside from the float mechanism and the choke.

Cylinder Throttle. The cylinder throttle, Fig. 100, serves a double purpose. First, the simple function of a throttle; and second, and of great advantage, as a variable venturi—a venturi that gives correct efficiency for any throttle opening. This throttle gives a very high velocity to the air stream at closed or semiclosed throttle position. As the throttle opens, it allows more air to enter—naturally at a decreasing velocity. This is a desirable condition for both low- and high-speed range. Furthermore, this throttle has another advantage—it allows a free, open, and unrestricted passageway for the air stream at wide-open throttle. The greater the volume of properly vaporized gas and air, the greater the power of the motor. This is termed volumetric efficiency.

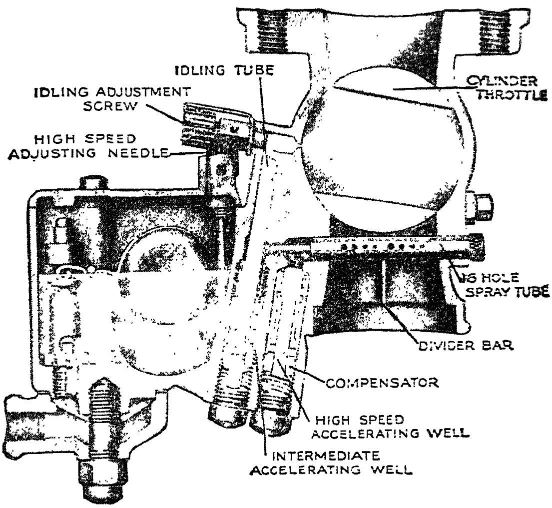


Fig. 100. Cross Sectioned View of Winfield Carburetor at Idling Position
Courtesy of Winfield Carburetor Company, Glendale, California

Sixteen-Hole Spray Tube. The Winfield carburetor employs a sixteen-hole spray tube, Fig. 101, in place of the conventional jet or jets. There are eight small calibrated holes on each side of this tube. The design of the tube is best understood by imagining that

it is a small pipe within a pipe. It is divided into two parts. The first eight holes draw mixture from the intermediate accelerating well; the second half of the tube is fed with fuel from the high-speed well.

The spray tube acts not only as a means of distributing and atomizing the fuel but also as a means of retaining a predetermined fuel-to-air ratio at the various throttle openings. This is accomplished by calibrating the holes in the spray tube so that, as the throttle is opened, the small holes are exposed first. The holes in the spray tube have a capacity area of many times the gasoline metering orifice and therefore do not form a restriction to the flow of liquid fuel. Consequently, any adjustment required in service can be made independent of the spray tube.

The purpose of this tube is to break the gas down into the finest of small particles. Naturally, the smaller the particles, the

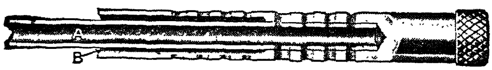


Fig. 101. Winfield Sixteen-Hole Spray Tube
Courtesy of Winfield Carburetor Company, Glendale, California

more perfect the final mixture. With this system there are no large drops of gas that are not mixed with the air stream. A multiple of small openings tend to atomize the gas more complete for mixing with the air. Since the accelerating wells are already bled with air, the gas enters the spray tube partially mixed with air. Thus the fuel is fed into the air stream as a foglike spray of tiny gas particles. By using this method, the Winfield carburetor supplies a mixture that approaches the theoretical ideal in vaporization—a mixture that assures complete combustion. The amount of gas that is supplied to the spray tube is regulated by the suction, the size of the air bleeders, and the size of the fuel metering orifice.

Accelerating Wells. For acceleration a sudden enrichment of the mixture is demanded. To accomplish this function the Winfield employs two accelerating wells of the air-bled compensating type. These wells serve as two reservoirs of extra fuel available for use to accelerate the motor. The well next to the float bowl is the inter-

mediate well and supplies the gas for idling and for the first half of the throttle opening. The other well is the high-speed well and supplies additional gas from half-open to wide-open throttle. At wide-open throttle, both wells deliver to their respective part of the spray tube.

Each accelerating well is compensated with fixed orifices which govern the depression in the well. Thus, the operation of the accelerating wells is entirely automatic and they will compensate themselves to meet any motor speed or motor load. Their rate of delivery depends entirely upon the vacuum and the velocity of the air flow.

The function of the air bleeder on each accelerating well is to govern the rate of gas discharge from the well and to control the suction on the fuel metering orifice. When the wells have been emptied, the setting of the intermediate-speed and high-speed adjustment needles and the size of the air bleeders control the amount of fuel that is delivered to the spray tube.

Idling. With the throttle in idling position, air is supplied from three sources—from the two slotted openings at the bottom of the cylinder throttle and through the opening at the idling-adjustment screw. This adjustment is an air bleeder which controls the idling-jet discharge by varying the vacuum applied to it. Since the intermediate well does not come into operation until the throttle is opened appreciably, it is necessary for the flow of fuel from the idling jet to increase slightly as the throttle is moved from a fully closed position to the position at which the intermediate well comes in. To accomplish this, carefully proportioned slots are cut in the throttle on its inlet side. These slots cause the vacuum on the idling jet to be greater when the throttle is slightly opened than when it is closed.

Rotary Throttle. By use of the rotary throttle in connection with this idling device, two things are accomplished. First, the mixing of the gas and air is made in the mixing chamber of the carburetor instead of in the manifold. Second, there is always a balanced ration of fuel and air for any idling speed because the variation of the suction is concentrated directly on the idling by-pass. This permits a very low idling speed. By the employment of this idling system, the transfer point from idling to delivery by the spray tube is even and smooth.

Idling to Half-Open Throttle. As the throttle opens wider and off the idling position, Fig. 102, it starts to uncover the spray-tube openings. The fuel is supplied from the intermediate well and the level of gas in this well drops. As the throttle reaches about one-third to half opening, the gas which has been held in the idling by-pass tube drops and furnishes an extra supply of gas to the intermediate well. This action affords a second stage of acceleration in the intermediate range.

Half- to Wide-Open Throttle. As the throttle passes the air passage divider, which is located at the half-open position, the added fuel is supplied from the high-speed well. See Fig. 103. The level in this well drops according to the vacuum applied. When a relatively high vacuum for wide-open throttle operation is reached, the well is empty. This occurs at a speed beyond which no further well action is required and is appreciably less than full speed. If the motor were then placed under a heavy load which would pull the car down to about five miles per hour, this level would come back up to the top of the relief in the compensator. With the arrangement and design of the high-speed compensator, there are two stages of synchronized acceleration in this well.

Installation. The Winfield carburetor is adaptable to any type of engine or special cylinder head, as shown in Fig. 104. Special adapting flanges are often necessary to make the installation, and to this end the factory makes up special package installations that are complete for each model and make of motor.

Servicing Winfield Carburetor. There are only three adjustments to make. There are no fixed jets or orifices to change. The "throttle cover side" refers to the side of the carburetor on which the throttle cover is held by three screws. The opposite side of the carburetor is referred to as the "body side."

After removing the old carburetor, take a file and clean the manifold flange. Have the manifold flange smooth and clean. When installing the carburetor be sure to use the new gasket which is furnished with this installation. Never use a gasket that is over $\frac{1}{64}$ inch thick. A thick gasket often warps the carburetor flange and this warping will cause an air leak that results in poor idling and poor low-speed performance. Above all, never use shellac or any other preparation on the gasket.

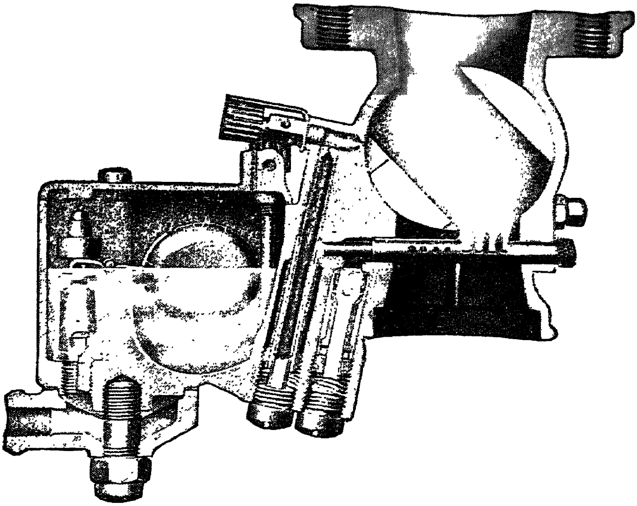


Fig. 102. Cross Sectioned View of Winfield Carburetor at One-Half Open Throttle
Courtesy of Winfield Carburetor Company, Glendale, California

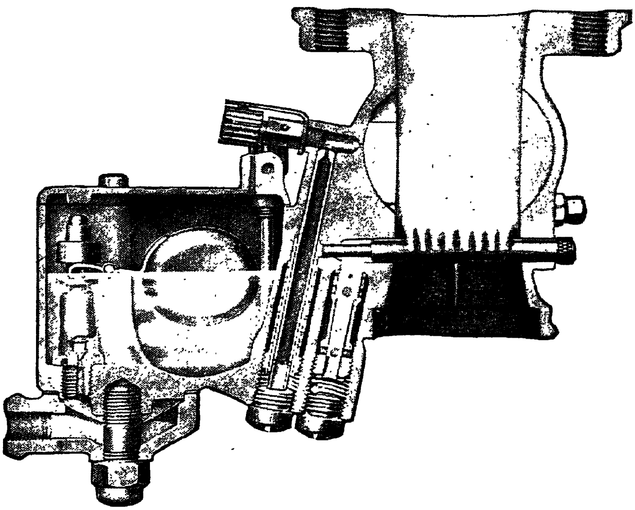


Fig. 103. Cross Sectioned View of Winfield Carburetor at Wide-Open Throttle
Courtesy of Winfield Carburetor Company, Glendale, California

Draw up the carburetor evenly and with equal pressure on both sides, that is, tighten the cap screws or nuts a small part of a turn on each side. By so doing the carburetor will be drawn up to the manifold evenly and snugly, thereby avoiding any tendency to warp the carburetor flange.

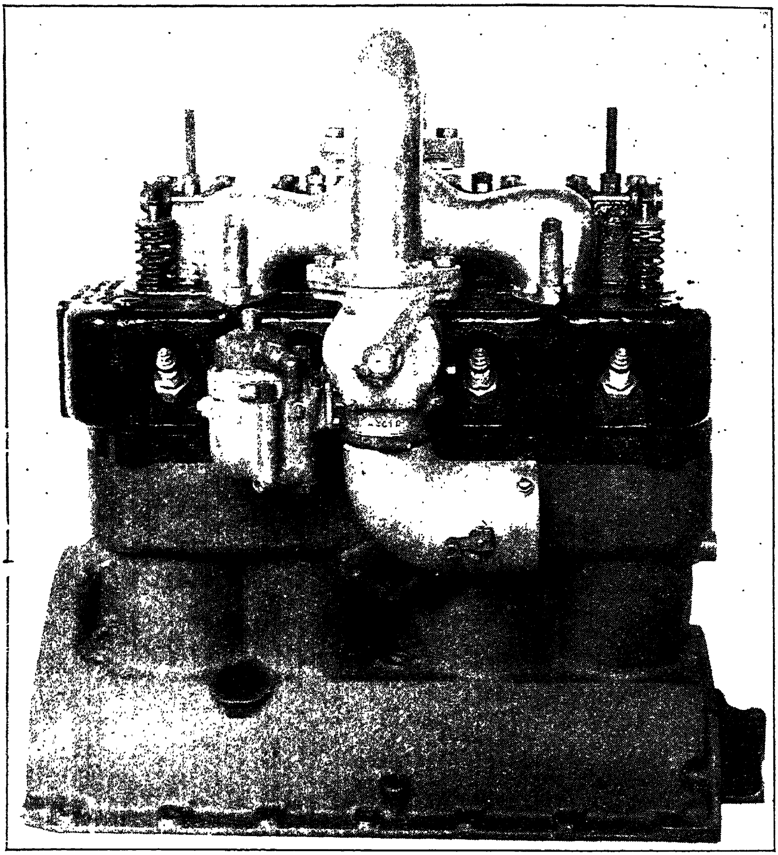


Fig. 104. Winfield Carburetor Fitted to a R and R Racing Head
Note the down-draft rivet flow intake manifold.

After connecting up the throttle rod to the throttle lever on the carburetor, make sure that the throttle on the carburetor opens to wide-open position when the foot accelerator is pressed down to the floor board. To determine if the throttle is opening to its

maximum limit, have some one step on the foot accelerator for you while listening to the carburetor. If you can hear the throttle hitting the stop, you know that it is opening to its maximum limits. This procedure is important because if the throttle does not open to its capacity, the car will not develop full power and speed.

When installing the silencer and choke, be sure to check the following points: With the choke on the instrument panel pushed in, the choke butterfly should be inspected to see that it is wide open. A partially closed choke after the motor is warmed up will ruin the gas mileage. Also, inspect the butterfly valve to see that it closes tightly when the choke button is pulled out for starting because if the choke is but partially opened, starting may be difficult.

Idling Mixture Adjustment. Always adjust the idling mixture with the spark retarded, motor hot. The idling mixture is controlled by the idling-adjustment valve. This adjusting valve is located just above the marking "low" on the float cover. This is an air adjustment which screwing it in or clockwise gives a richer mixture and screwing it out or counterclockwise gives a leaner mixture.

Idling-Speed Adjustment or Throttle-Stop Adjustment. The hexagonal brass set screw with the brass lock nut, which is located on the back of the body side and at the bottom of the throttle, regulates the idling speed. If after adjusting the idling valve to the proper mixture the motor idles too fast, screw the throttle stop outward until the desired speed is reached. If the motor idles too slow and stalls, the stop should be screwed inward. Never attempt to vary idling speed with the idling-adjustment valve, but use the throttle stop. Set the idling speed fast enough so there is no tendency for the motor to die when the throttle is closed quickly. The throttle stop is locked by the throttle stop nut.

The flow of gasoline from the float bowl in the two accelerating wells is regulated by two adjustable needles. The needle valve adjacent to the mark "INT" on the float cover controls the flow of gasoline to the intermediate well; the needle adjacent to the mark "high" on the float cover controls the flow of gasoline to the high-speed well.

Before making other adjustments, screw the high-speed and intermediate adjustment needles down in a clockwise direction

until they just barely seat. **Do not screw these needles down too tight** because too much force will distort the float bowl cover and gouge out the needle seat. Turn them down just to the point where there is a slight resistance.

Intermediate Adjustment. The intermediate speed or economy adjustment is controlled by the needle adjacent to the mark "INT" on the float cover. Turning this needle up in an anticlockwise direction gives more gasoline. Open this needle two full turns—there are 16 notches to each turn. To obtain an exact adjustment, advance the spark lever to normal driving position, set the throttle hand lever on the steering wheel to a position which is about one-third open, then screw this needle down until the motor slows down. Then open this needle one notch at a time until the motor attains its maximum speed with minimum opening of the intermediate needle. This should give you a good average adjustment. Two notches less opening may give your customer better economy for continuous driving or touring.

To check this adjustment, screw the intermediate adjustment down two notches. If the motor slows down just slightly, the former setting was correct. Screw the needle up and back to its original setting. If the motor does not slow down when the needle is turned down two notches, it is adjusted too rich. In this case continue to turn the needle down until reaching the point where there is a slight slowing down of the motor, then back two notches.

High-Speed Adjustment. Turn the high-speed adjustment needle up in a counterclockwise direction to the same number of notches as the setting for the intermediate needle. There is only one way to make this setting correctly and that is to try the car out on the road—preferably on a hill. Run the car at wide-open throttle and see how it performs. Then open the high-speed adjustment needle up two notches at a time to see if there is an increase in power. Repeat this operation. When the point is reached where there is no additional increase in power, it is advisable to turn the needle back two notches.

If the high-speed adjustment is adjusted too lean, the motor will hesitate and will not pick up to its maximum speed at wide-open throttle. If the adjustment is too rich, the motor will be sluggish, that is, it will be slow in getting under way.

Float Level. The float level on a Winfield carburetor should be $1\frac{9}{16}$ inch from the top surface of the float bowl. This measurement must not be made along the side of the bowl because the capillary action holds the gas up on the side of the bowl.

Oil Throttle Bearings. While the motor is idling, oil both ends of the throttle shaft at the throttle bearings with ordinary engine oil. Repeat this operation every 500 miles.

Caution. The carburetor does not change in adjustment. Once it is correctly set, it should then be left alone. If the motor starts to miss and act improperly, first check the ignition carefully. Then check the gasoline lines and vacuum tank or fuel pump. Then drop the strainer bowl of the carburetor and clean the strainer screen with compressed air. Be careful not to damage this fine mesh screen. Put the strainer bowl back again and see if the motor does not again function properly.

BUICK-STROMBERG A-A CARBURETOR

The Stromberg Series A-A carburetor is of the duplex downdraft type of aircraft design. It has been adopted as standard equipment for a number of production cars. The model is used on all Buick cars for 1937. The Buick model is described here, but the reader needs to remember that while the general principle of operation of all of the A-A Series is quite similar, there must be certain minor differences in the different models supplied to different cars. Engines with larger displacement require more fuel than engines with a smaller displacement. Inherent characteristics of engine design also must be met and satisfied by carburetor design, so that uniform power curves as representing engine performance may be developed by the engineers. However, the service man is interested primarily in knowing the fundamental features of construction and adjustment. The principle of operation of the A-A carburetor is the plain tube using air-bled jet to maintain the proper mixture throughout the entire range of operation. A study of Figs. 105 to 107 will show that the fuel chamber completely surrounds the entire carburetor body. This feature is incorporated in order to insure a proper level of fuel under varying conditions of operation. Baffles are supplied in the float chambers designed to prevent undue surging of the fuel on sharp, sudden turns. The float lever is so connected to

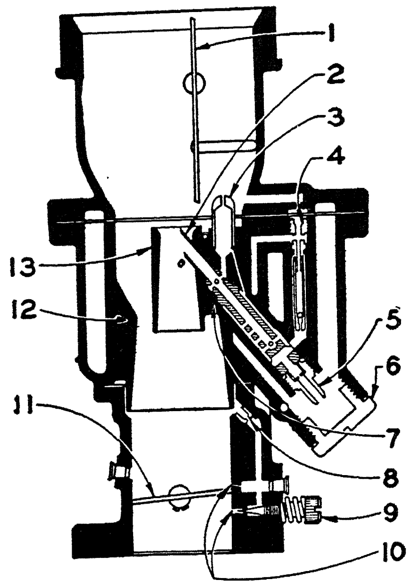


Fig. 105. Part Sectional View through Buick-Stromberg Carburetor Showing Main Metering Jet No. 5. Other parts shown in this figure and in Figs. 106 and 107 are as follows:

1. Choke Valve
2. Main Discharge Jet
3. High-Speed Bleeder
4. Idle Tube
5. Main Metering Jet
6. Main Discharge Jet Plug
7. Main Discharge Jet Gasket
8. Idle Air Bleeder
9. Idle Needle Valve
10. Idle Discharge Holes
11. Throttle Valve
12. Primary Venturi
13. Auxiliary Venturi
14. Float
15. Float Lever
16. Float Needle Valve Clip
17. Float Fulcrum Pin
18. Float Needle Valve
19. Float Needle Valve Seat
20. Float Hanger Gaskets
21. Float Hanger
22. Float Chamber Vent
23. Pump Fulcrum Arm
24. Pump Piston Link
25. Felt Dust Washer
26. Retainer Washer
27. Dust Washer Spring
28. Spring Retainer Washer
29. Pump Duration Spring
30. Pump Piston
31. Pump Expansion Spring
32. Pump Relief Valve
33. EconomizerBy-PassValve
34. Pump Inlet Check Valve
35. Pump Discharge Channel
36. Pump Discharge Nozzle
37. Spark Control Hole
38. Fuel Level Sight Plug
39. Throttle Stop Screw
40. Pump Rod

the float needle valve that it is positive acting at all times. To facilitate the checking of the level of the fuel, a removable plug has been provided.

As indicated by the name A-A, these models are really two carburetors built into one. There are two sets of venturi tubes, a main metering jet, an idle system with an adjusting needle, a throttle valve, and a pump discharge nozzle for each barrel. Both barrels

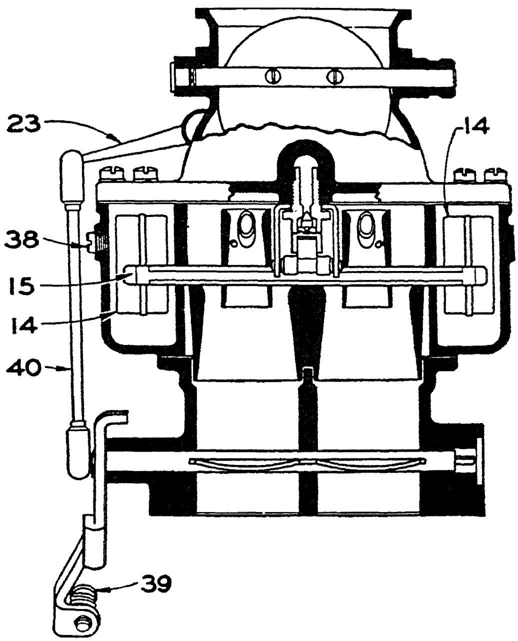


Fig. 106. Buick-Stromberg Carburetor Showing Double Venturi and Barrels

are supplied with fuel by one float chamber. There is only one air inlet.

With the engine operating, the idling system supplies all the fuel used at idling speed and also on part throttle up to approximately 22 miles per hour, from which point to approximately 75 miles per hour on part throttle all of the fuel is supplied through the main metering system. The additional fuel necessary for speeds above 75 miles per hour and on all wide-open throttle operations is sup-

plied through the economizer valve. An accelerating pump is connected directly to the throttle and this taken in connection with the economizer tends to assure proper engine performance under all operating conditions.

Main Metering System. With the engine turned over by the starting motor, fuel is forced through the fuel line from the fuel pump into the carburetor bowl. The float needle valve *18*, Fig. 107,

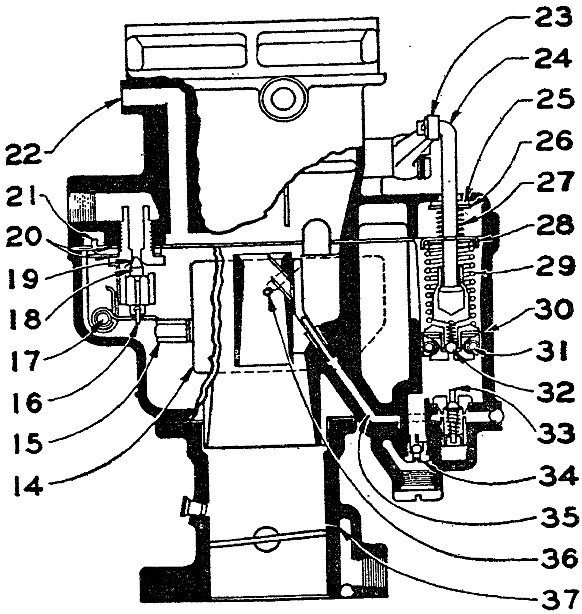


Fig. 107. Buick-Stromberg Carburetor Showing Accelerator Well and Pump

and the float needle valve *19* in connection with the float maintains the fuel at a constant level.

The choke appears as *1* in Fig. 105, and the throttle butterfly valve is indicated as *11* at the bottom of the carburetor barrel, two of these being used — one in each barrel. Since this is a down-draft carburetor, air enters at the top through the air inlet and when passing downward through the carburetor places suction on the main discharge jet *2* or the idle discharge holes *10* depending upon the amount of throttle opening. The main metering jets *5* are of the fixed type. They control the flow of gas during the intermediate or

part throttle position up to approximately 75 miles per hour. After being drawn from the metering jet, the fuel passes to the main discharge jet *2* where it is mixed with the air from the high-speed bleeder *3* and flows into the carburetor barrel down to the intake manifold.

The intake manifolds of the Buick engines are of the twin type integrally cast. The outside branch of the manifold supplies cylinders 1, 2, 7, and 8 and the inside branch supplies cylinders 3, 4, 5, and 6. An exhaust jacket is cast around the center section and is connected with the exhaust system, this being designed to assist carburetion by the addition of heat to the incoming fuel as it

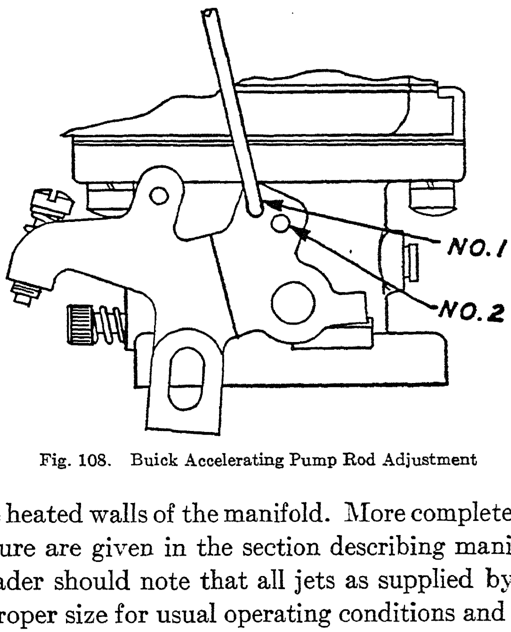


Fig. 108. Buick Accelerating Pump Rod Adjustment

contacts the heated walls of the manifold. More complete instructions on this feature are given in the section describing manifolds.

The reader should note that all jets as supplied by the factory are of the proper size for usual operating conditions and it is not recommended that any changes be made in these jet sizes without special instructions from the factory.

Maximum Power. For a part throttle opening, fuel is supplied through the main metering jet to approximately 75 miles per hour, at which point the economizer valve *33*, Fig. 107, is forced down by the accelerating pump piston allowing fuel to flow through the economizer valve and discharging through the pump discharge nozzle *36*. Fuel is supplied continuously through these passages

with the throttle wide open, so that for maximum power or high-speed running a richer mixture is supplied than is supplied for the normal throttle opening.

Accelerating Pump Adjustment. With ordinary fuels the accelerating pump link, Fig. 108, is connected in the No. 1 hole. The No. 2 hole affords a shorter accelerating pump stroke but does not affect the opening of the economizer valve. This shorter stroke is recommended in order to prevent a staggering or too rich operation, as would be the case with too rich a charge of acceleration. Highly volatile fuels are usually marketed through the winter season so that it may be necessary to make the change from the No. 1 to the No. 2 hole for winter operation. However, it will be necessary for best operation to change back from the No. 2 to the No. 1 for summertime operation when the regular fuels are more generally available. Unless richness is encountered in operating in the No. 1 hole, never make the change to the No. 2.

Idle Metering and Adjustment. When the engine is operating on idle speed, fuel flows from the idle tube *4*, Fig. 105, where it is mixed with the air, from the air bleeder at the top of the idle tube. This mixture passes to the idle channel where additional air is mixed with it to the secondary idle air bleeder *8*. It is then discharged through idle holes *10*. On closed throttle, fuel is drawn from the lower idle discharge hole due to the high suction at this point. As the throttle is opened, suction is also placed on the upper idle discharge holes to feed additional fuel until the throttle is opened to the position where the main discharge jet comes into operation. Before making the adjustment of the idle needle valve, the engine should be well warmed up so that the intake manifold is warm to the hand and the throttle stop screw is on the slow idle. An idle speed of approximately 7 to 8 miles per hour is recommended. This is secured by adjusting the stop screw *39*, Fig. 106. Fuel for the low speed adjustment is controlled by means of the idle needle valves *9*, Fig. 105. Turning the needle in will give a leaner mixture and turning it out will give a richer mixture. The best plan is to take one barrel at a time and turn the idle adjustment in slowly until the engine begins to lag or run irregularly, after which the needle is slowly turned out until the engine begins to roll or show signs of richness. The last step is to slowly turn in the adjustment again

just enough so that the engine runs smoothly for this particular throttle opening. After the adjustment of one set of four-cylinders has been secured in this manner, the other idle needle valve should be adjusted for the remaining cylinders. It may be necessary after making these adjustments to adjust the engine idle speed with the engine idle screw to a slight degree.

Another method of adjusting idle speed is to cut off the engine after it has been warmed, turn in on the idle screws until they are closed. The closed position can be felt when the idle screws seat as they are turned with the screwdriver. Under no circumstances force the screws on the seat, as this will cause damage. From the closed position the screw should be turned out $1\frac{3}{8}$ turns on the Series 40 and $1\frac{1}{4}$ turns on the Series 60-80-90 carburetors. It will be found that the idle mixtures thus secured will be approximately correct for the 7 to 8 miles per hour idle speed. If it is desired to adjust the carburetor further, it is suggested that each screw be turned the same amount and in the same direction until the desired results are obtained. Under no circumstances should these screws be turned more than a slight amount at a time. This method will give equal setting for both sides of the system.

Acceleration. Acceleration requires additional power and this is secured only by burning additional fuel. Thus, on acceleration it is necessary to supply momentarily an extra amount of fuel as the throttle is opened. The action of the accelerator pump is one of drawing in fuel on the upstroke of the pump piston *30*, Fig. 107. Fuel enters the piston chamber through the inlet valve *34*. On the downstroke of the pump piston, the compression closes the check valve and forces open economizer valve *33*. This allows the fuel to be discharged through the pump discharge nozzle *36* into each of the carburetor barrels. Part open throttle allows only a small amount of fuel to be discharged, while the wide open throttle allows a greater amount of fuel to be discharged.

Fuel Level. Normal factory setting for the fuel level is $\frac{5}{8}$ inches below the top surface of the float chamber which corresponds to the bottom level of the sight plug *38*, Fig. 106, with the engine idling. The float *14* and the float needle valve *18* operate to control the fuel level in the float chambers. If there is question of the fuel level being correct, the plug should be removed in order to observe the

position of the level before the carburetor is removed and disassembled. It should seldom be necessary to make a change in the fuel level, but if it does become necessary and the inspection shows the need of such change, the level is secured by bending the float lever arm so as to secure the level desired. It is important to remember that the float level must be checked only while the engine is running.

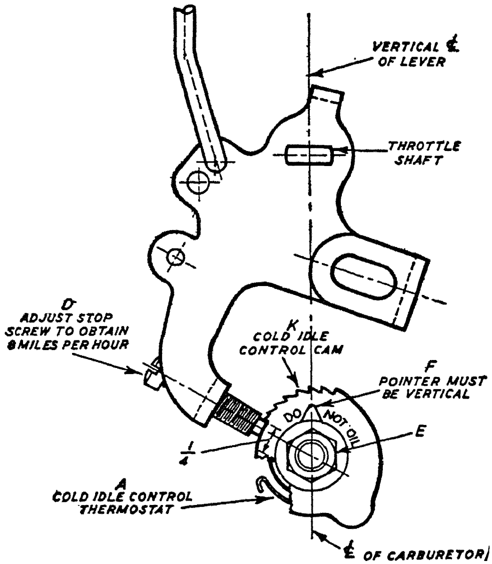


Fig. 109. Buick Cold Idle Control

Cold Idle Control. The cold idle control is designed to provide a faster idle speed during the warm-up period of the engine which insures adequate lubrication for the engine and prevents stalling. The speed of the engine increases or decreases as the temperature of the manifold changes. The cold idle control consists of a thermostatically operated cam *K*, which is shown in Fig. 109. This is mounted on the intake manifold heat jacket. This cam serves as a stop for the throttle stop screw *D*. The variable speed mentioned is secured by using the thermostat *A*, which drives the cam *K*. When the riser is cold, the thermostat *A* rotates the cam *K* in a counter-clock-wise direction, causing its thick side to contact with the idle

stop screw *D*, which serves to speed up the engine. Now as the riser warms up, the thermostat is heated and thus revolves the cam *K* in a clock-wise direction until the idle screw *D* is contacting with the cam *K* at its thinnest section, causing the carburetor throttle to close to the normal, hot idle speed. Ordinarily it will not be necessary to adjust the cold idle control. However, it may be checked by loosening the nut *E* and rotating the cam hub in the direction necessary to place the pointer *F* directly above the nut *E*. This adjustment may be made regardless of the manifold temperature. A momentary opening of the throttle is necessary to allow the cam *K* to adjust itself for any temperature position. This is because

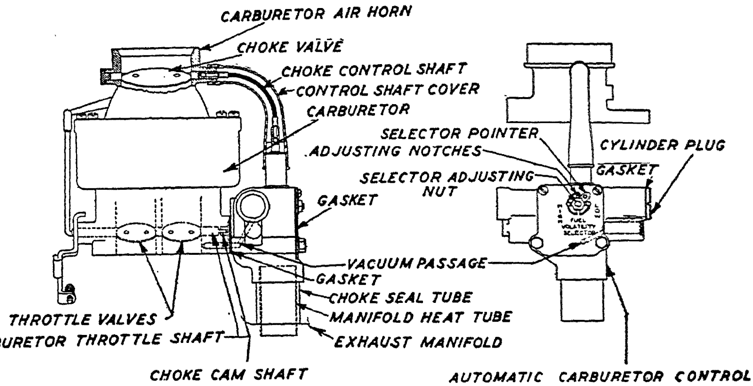


Fig. 110. Delco-Remy Automatic Opposed Piston Type Carburetor Control

the spring *A* is not capable of rotating the cam *K* while the idle adjusting screw is contacting the cam. After the engine has been warmed up, the throttle stop screw *D* should now contact the cam *K* on its thin portion, and within the $\frac{1}{4}$-inch limit adjoining the first raised section of the cam as shown in Fig. 109. In case the throttle stop screw does not contact within the limits shown, the cam hub with the pointer attached may be rotated slightly in order to bring the $\frac{1}{4}$-inch section under the idle screw. If it is necessary to rotate the pointer more than 5 degrees from its former vertical position, a complete new cam assembly should be installed. It is important to see that no oil is used on the cold idle cam.

Proper Idle Speed Important. The idle speed of 7 to 8 miles

per hour is recommended because this speed is sufficient to prevent stalling of the engine, while driving the car at low speed. It will provide positive circulation of the cooling solution through the cooling system and it also operates the fan at a speed assuring flow of air through the radiator core. It provides proper lubrication while the engine is cold. The engine will operate more smoothly and maintain a uniform high intake manifold vacuum at this speed. This is necessary to prevent the starter clashing as a result of not maintaining the vacuum on the manifold starter switch which holds the switch out of contact. It also provides more quiet engine operation by preventing backlash in the operating parts of the engine.

AUTOMATIC CARBURETOR CONTROL

Delco=Remy Opposed Piston Type. This type of Delco-Remy Automatic Carburetor Control is mounted on the back side of the carburetor above the exhaust manifold. Fig. 110 shows how the control is mounted in relation to the carburetor and also the interconnections between the control and the carbureting system. The purpose of the carburetor control is to maintain automatically the correct fuel mixture in the carbureting system under varying temperature conditions both inside and outside the engine.

The operation of the automatic carburetor control is governed by variation of manifold temperature, intake manifold vacuum, carburetor air inlet velocity, and throttle opening. The "choking" action is obtained by means of a choke valve in the carburetor air horn which is connected directly to the control shaft shown in Fig. 110. Each of the four factors affecting the operation of the control will be considered separately. It must be remembered that in actual operation all four of these factors may be working together to produce the desired result.

Manifold Temperatures. Since the greatest need for variation in fuel mixture is due to variation in temperature and since the temperature changes are rapid during the "warm-up" period, the master control is temperature. The temperature control is obtained by means of a helical thermostat which is wound around and secured directly to the thermostat shaft by means of the thermostat calibrating screw. The thermostat shaft in turn is connected to the choke valve in the carburetor air horn through a flexible control shaft, as

shown in Figs. 110 and 111. The other end of the thermostatic spring is connected through a gear and rack to a spring loaded vacuum piston which is operated by a manifold vacuum. The thermostatic spring is so wound that with decreasing temperature it tends to close the choke valve and with increasing temperature it tends to open the choke valve. The control is mounted so that one end of the thermostat extends into a heat tube on the exhaust manifold. This feature allows changes in manifold temperatures to be quickly transmitted to the control unit mechanism. The thermostatic spring is calibrated so that the proper "choking" action is obtained at various operating temperatures. At temperatures of

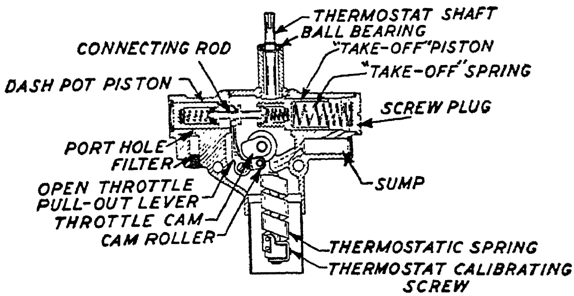


Fig. 111. Sectional View of Delco-Remy Carburetor Control Showing Pistons

85 degrees Fahrenheit or below, the choke valve completely closes the carburetor air horn passage, and at normal engine operating temperatures (after the "warm up" period) the choke valve is completely open. The temperature control, although it is positive in action and covers the complete "choking" range, must be aided by one or more of the other three factors under various cranking and operating conditions.

Intake Manifold Vacuum. The amount of vacuum in the intake manifold of the engine varies with the amount of load on the engine. When the engine is pulling heavily, the amount of vacuum is much smaller than when there is little or no pull on the engine. This variation in vacuum is used to operate the "take-off" piston in the control unit, as shown in Figs. 110 and 111. When there is little or no vacuum being created in the engine manifold, the take-off piston is held forward toward the center of the control unit by the

"take-off" spring. As the amount of vacuum increases, the take-off piston is pulled back in its cylinder accordingly. This movement is retarded to some extent due to the action of the dashpot piston which is secured to the opposite end of the connecting rod. The movement of the "take-off" piston and dashpot piston is transmitted to the thermostat through a gear and rack arrangement, Fig. 112. Thus, any movement is transmitted through the thermostat and shaft directly to the choke valve.

Carburetor Air Inlet Velocities. As the engine starts to run, the increased air flow through the carburetor air horn tends to open the unbalanced choke valve. The air velocities on the unbalanced choke valve correct the mixture for varying engine speeds.

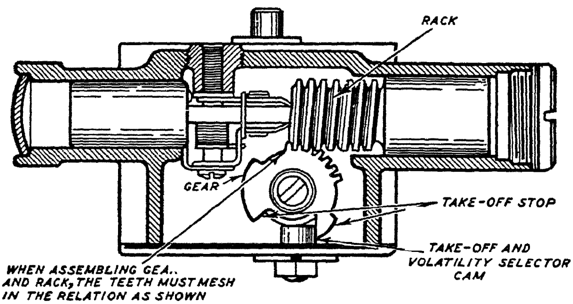


Fig. 112. Delco-Remy Rack and Gear

Throttle Opening. The carburetor throttle shaft is connected directly to the choke camshaft, as shown in Fig. 110. Thus, the movement of the throttle is transmitted through the choke camshaft, throttle cam, cam roller, and pull-out lever to the connecting rod and linkage between the "take-off" piston and dashpot piston. The movement somewhat modified by the other controlling factors, according to operating conditions, passes through the gear and rack, thermostat and shaft to the choke valve. This action is not transmitted to the choke valve immediately due to the retarding action of the dashpot piston. The movement of the throttle cam loads the pull-out lever spring and the tension of this spring on the pull-out lever gradually moves the dashpot piston forward in its cylinder. See Fig. 111. The port hole in the dashpot piston cylinder allows

this action to speed up after the piston has reached this point. The full movement of the dashpot piston is completed in 7 to 10 seconds. The return of the piston to its original position requires a maximum of one minute.

In the above discussion the operation of each individual part of the control has been covered. When the engine is in operation the amount of "choke" obtained at any one instant is a combination of the above features.

Starting the Engine and the "Warm-Up" Period. When the engine is not running, the choke valve is positioned by the thermostatic spring according to temperature. At 85 degrees Fahrenheit or below, the choke valve is closed. As the starter pedal is depressed, closing the starting motor contacts and opening the throttle, the "choking" action is quite heavy depending on the temperature. By this action enough fuel is injected into the cylinders to insure easy starting. Under ordinary conditions the engine will start in 1 to 3 seconds. As the engine fires and continues to run the increased heat on the thermostatic coil, the greater air velocity through the carburetor air horn, and the increased vacuum in the take-off piston cylinder all tend to open the "choke" valve and decrease the amount of "choke." If the motor is accelerated or pulled heavily during the warm-up period, the variation in vacuum, air velocity, and throttle position operate the various parts of the control so that the choke valve is positioned correctly. As the temperature increases and the desirability of a richer mixture decreases, the thermostatic spring opens the choke valve more and more until the wide open position is reached. The engine is now at normal operating temperature and the control has no further function until the engine is stopped again.

Since the throttle and starter switch are actuated by the same foot pedal, the connection of the choke mechanism with the throttle shaft provides desirable starting features especially in cold weather. These features are as follows: delayed dechoking with wide open throttle, and ability to "lug" or pull the engine cold indefinitely without upsetting the correct mixture ratio.

Delayed Dechoking with Wide Open Throttle. When the engine does not start immediately and prolonged or repeated cranking is necessary, it becomes important that a dechoking action take

place so that too much fuel will not be drawn into the cylinders. This is accomplished by the delayed action of the dashpot piston. If the engine has not started in 7 to 10 seconds, the dashpot piston has traveled to the point where it begins to push the take-off piston into its cylinder thereby moving the choke valve through the thermostat and leaning out the cranking mixture. On repeated cranking, with short intervals of time between each one, the "dechoking" action takes place much quicker because the dashpot piston has not had time to travel completely back to its original position. This is desirable because the mixture is already rich enough.

Maintaining correct mixture ratio on acceleration or when pulling the engine cold is also accomplished by the action of the dashpot piston. On opening the throttle, the vacuum decreases and the "take-off" spring tends to push the "take-off" piston forward in its cylinder thus moving the choke valve toward the closed position to give the necessary enrichment for solid acceleration when cold. If this action were continued on a long pull, the mixture would become too rich. Since the throttle is near the wide open position in this case, the dashpot piston will push the take-off piston back into its cylinder after 2 to 3 seconds, positioning the choke valve again for the correct mixture ratio.

Adjustments. All units are properly calibrated at the factory and should require very little attention in service. If, however, abnormal conditions or incorrect adjustments do arise, a definite procedure of checking and adjusting should be followed.

Fuel Volatility Selector. The fuel volatility selector is provided to take care of variations in fuel volatility encountered in various brands of fuel. The adjusting mechanism is located on the cover plate and adjustments can be made without disassembling the control unit. The selector pointer for regular gasolines is set as shown in Fig. 110. That is, one notch from extreme "low" volatility. The three notches toward the "high" position provide ample adjustment to cover the most volatile brands of gasoline, if the car owner prefers to use them. When the choke is adjusted for highly volatile fuels, the adjustment will be too lean for regular blends, and will cause "popping" or "spitting." Whenever the adjustment is changed, this fact should be explained to the owner. Setting the selector in

the low volatility position gives a richer mixture, in the high volatility position gives a leaner mixture.

Check Control on Car. If the engine is not operating as it should and the carburetor control is thought to be at fault, the unit should be checked on the engine. Such a check will definitely determine if the trouble is in the control or whether it should be looked for elsewhere about the engine. Since the moving parts of the control are completely enclosed, it is necessary to remove the air cleaner to check the action of the unit on the engine. With the air cleaner removed, it is possible to observe the action of the choke valve, Fig. 110. The following observations should be made before the unit is removed from the engine. First, the choke valve should be free and when opened or closed manually should return to its original position. With the engine cool and stopped, push the throttle wide open. After a delay of 7 to 10 seconds the choke valve should slowly move toward the open position. Close the throttle and the choke valve should return at once to its original position. If the action described above is not obtained, a check should be made for binding or sticking pistons.

Next, start the engine when cool. The choke valve should move toward the open position as the engine starts to run. If this is not the case, check for obstructed vacuum passage, leakage at the choke gasket due to loose attach ng bolts, vacuum leak around the screw plug in the end of "take-off" cylinder due to looseness or damaged gasket, or sticking pistons. Accelerate the motor while it is still cool. The choke valve should move toward the closed position momentarily and then resume its original position. Failure to do so indicates sluggish dashpot piston, weak or broken dashpot piston pull-out lever spring, or binding in moving parts.

If the choke valve has performed as outlined above, the control is operating properly; if not, the unit should be removed from the engine and checked further.

Disassembling Control Unit. In removing the carburetor control from the engine, it is best to remove the carburetor and choke assembly from the manifold. The choke control shaft cover can be pulled back from either end and the flexible control shaft slipped out with it. After the choke has been removed from the carburetor, the cover plate can be removed by loosening the two attaching screws exposing

the moving parts as shown in Fig. 111. It is very important that moving parts be free and that pistons are clean and do not stick in the cylinders.

The "take-off" and dashpot piston assembly can be removed without disturbing the thermostatic calibration if the proper procedure is followed. Remove the dashpot pull-out lever by removing its pivot screw. Remove the take-off cylinder plug and take-off piston spring. The piston assembly can then be pushed toward the open end until the rack and gear disengage. The thermostat shaft and gear assembly can then be turned approximately 180 degrees so that the dashpot piston will clear the gear as it is pulled out through the "take-off" cylinder. Looking through the thermostat opening in the bottom of the casting will assist in this operation as care should be taken not to scratch the dashpot piston as it passes the gear.

If the pistons are dirty or sticky, they should be wiped off with a clean soft cloth. The cylinders should be carefully wiped out with alcohol, if necessary, and should be thoroughly dry before reassembly. Check the flexible linkage between the two pistons for free operation at both ends. While the pistons are removed, rotate the thermostat shaft and gear assembly to be sure it is free in its bearings.

Before reassembling be sure that the vaccum passages in the choke casting and carburetor throttle body are open. The use of compressed air is satisfactory for this purpose if the air system is entirely free from water, oil, and rust; otherwise it may be very harmful.

TILLOTSON CARBURETOR

Arrangement of Nozzles and Functioning Parts. There are two sources of mixture delivery. At *A*, Fig. 114, is the by-pass or low-speed nozzle tube and at *B* the main or high-speed nozzle. Gasoline enters the carburetor through connection *C*, passes the strainer *D* and the inlet needle valve *E*, from whence it delivers into the float bowl chamber *F*. When the fuel reaches a point $\frac{13}{16}$ inch from the top edge of the float bowl, the float acts upon the needle *G*, closing off the supply. From the float bowl, the gasoline enters channel *H*, flows upward through the main nozzle adjustment restriction *I*, across channels *J* to the head of the by-pass

nozzle and into the accelerating well above at *K*, seeking by gravity the same level held in the float bowl. It being important to the function of the carburetor that the fuel level be carefully maintained, close study should be made of the chamber and channels filled with gasoline, noting especially where fuel is present and where there is none.

Operation of Low Speed and By-Pass. As the engine is revolved in the operation of starting, the suction induced by the reciproca-

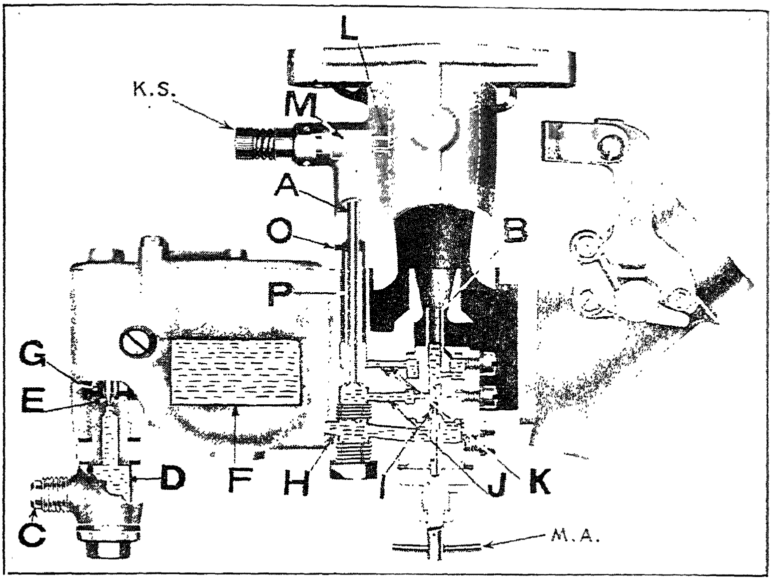


Fig. 114. Cross Section of Nozzles and Other Constructional Features of the Tillotson "S-4D" Carburetor

tion of the pistons within the cylinders, timed by valves in the poppet type of motor, creates a vacuum above the throttle shutter. Connecting the throat above the shutter with the by-pass mixing chamber *M* is a small hole at *L*, Fig. 114. Suction induces an emulsion of gasoline and air to pass upward through the by-pass tube to the mixing chamber *M* where air is again admitted through low-speed adjustment *KS*, causing the emulsion to be turbulated and drawn through hole *L* at high velocity. Thus the idling mixture requirements are satisfied.

As the throttle is advanced or opened slightly, a second and larger hole immediately below the upper hole is uncovered by the shutter. A suction now acts upon this hole which induces a secondary mixture to be added which unites with the air passing the throttle shutter and thus satisfies the requirements for increased engine speed. Mixture for idling and low-speed engine needs is provided in this manner up to a point where the partial vacuum, created at the small venturi surrounding the main nozzle, is sufficiently great to draw a third source of supply from this point. With further advance of the throttle, partial vacuum gradually decreases at the by-pass holes and increases at the main nozzle, with the result that the mixture delivery falls off at the by-pass and increases at the main nozzle.

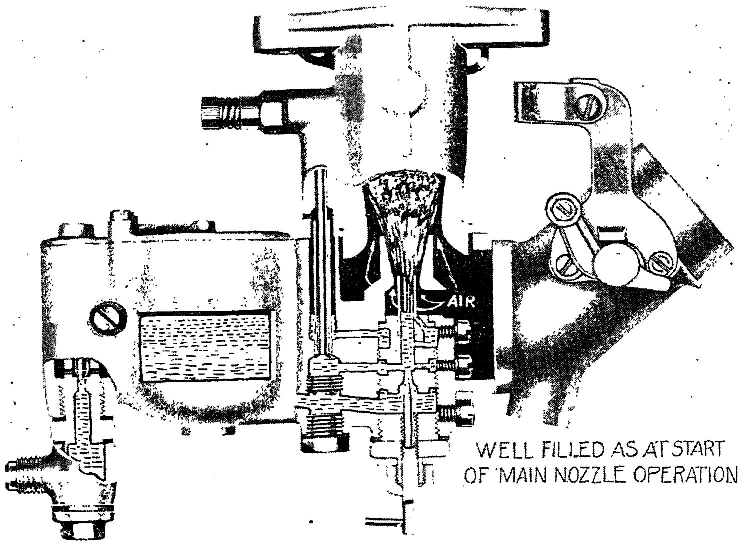


Fig. 115. Operation of Tillotson High-Speed Jet

Operation of Main Nozzle. As the fuel begins to deliver from the high-speed jet, see Fig. 115, the fuel standing in the accelerating well surrounding the by-pass tube is drawn back through channel *K* into the upper cross holes of the main nozzle. When the well is emptied, these holes act as air-bleed nozzle restrictions in helping

to emulsify the fuel drawn out of the main nozzle. A close study of Fig. 116 will disclose that the source of air which bleeds these nozzles comes from a small hole in the upper half of the body casting at *O*, Fig. 114. Air passes into this hole downward between the auxiliary tube *P* and the body casting, thence across channel *K* into the main nozzle.

All gasoline delivered through the main nozzle now has its source of supply through adjustable needle restriction *I*, and fuel

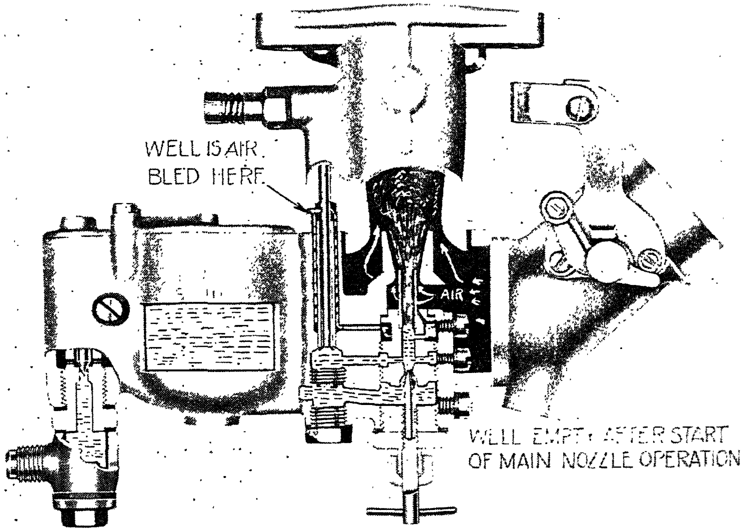


Fig. 116. This Illustration Shows the Accelerating Well Dry and Air Bleeding through It to the Main Jet

delivery is automatically regulated by the degree of suction imposed at this nozzle through the relative open or closed position of the throttle shutter. With the closing of the throttle, suction is transferred to the by-pass, fuel then having its source through the channel *J* to the head of the by-pass nozzle. The accelerating well again fills by gravity.

Acceleration. Gasoline in reserve supply, which stands in the well *K* during low-speed idle operation, awaits the sudden opening of the throttle; at which time it is drawn upon to temporarily enrich the mixture for power requirements.

FORD "V-8" DUAL CARBURETOR AND MANIFOLD

Ford "V-8" Dual Manifold. The 1934 passenger cars were the first to be equipped with a dual down-draft carburetor, Fig. 117,

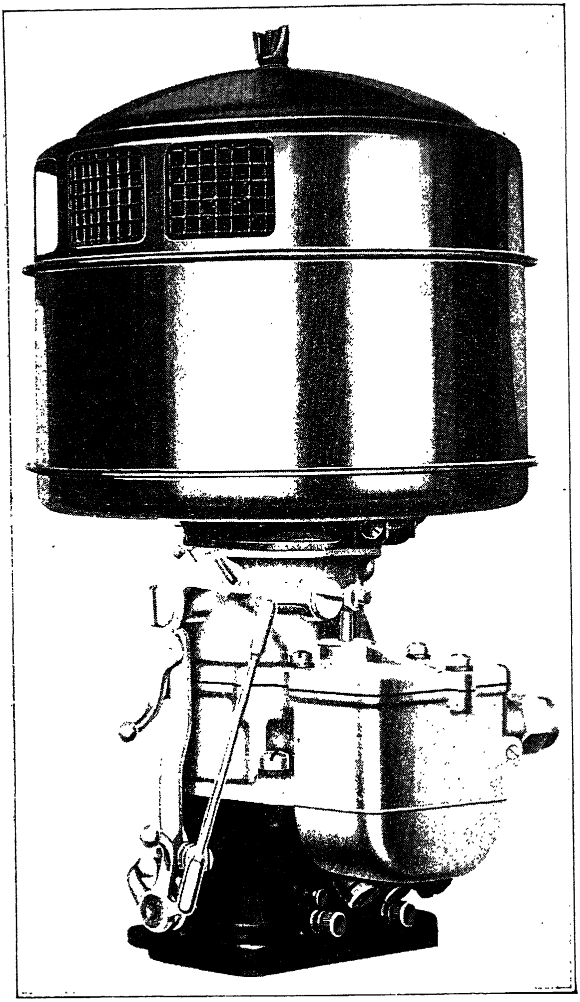


Fig. 117. Ford "V-8" Carburetor and Air Cleaner

and dual intake manifold, which give the same results as would be obtained from two separate 4-cylinder manifolds and carburetors. Fig. 118 shows the intake manifold for the right-hand barrel of the

dual carburetor in heavy lines. This portion of the intake manifold supplies the fuel-air mixture to cylinders *1*, *4*, *6*, and *7*. Fig. 119 illustrates the intake manifold for the left-hand barrel of the carburetor which supplies the fuel-air mixture to cylinders *5*, *8*, *3*, and *2*.

With the exception of a small passage-way between the two manifold cores, at the windshield wiper and distributor vacuum brake connections, the two intake manifolds are entirely independent of each other and not connected. These connecting passage-ways at the windshield wiper and distributor vacuum brake connections serve the purpose of steadying the vacuum at these points, giving the steady vacuum characteristics of an 8-cylinder engine. If these two manifolds had not been connected at these points, the vaccum for the windshield wiper and the distributor vacuum brake would be unsteady at low speeds, as with 4-cylinder engines. The use of

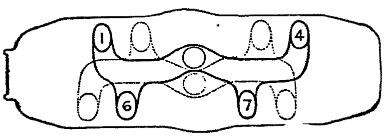


Fig. 118. Firing Order—Right-Hand Barrel of Carburetor

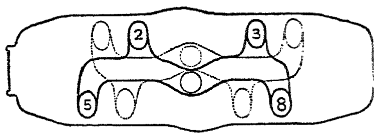


Fig. 119. Firing Order—Left-Hand Barrel of Carburetor

this type of manifolding increases the power output and makes for more even engine operation.

Ford "V-8" Dual Carburetor. The dual carburetor, Fig. 117, used on 1934 Ford "V-8" cars, uses one float chamber and float valve, one choke valve, and one accelerating pump. The discharge, however, from the accelerating pump is equally divided between the two carburetor barrels. To simplify the carburetor explanation, the one barrel of the carburetor only will be explained, as the operation of both is identical.

Idling—Fuel Supply. The fuel from the carburetor bowl passes through the main metering jet and is drawn upward as indicated by the arrows in Fig. 120. Air enters this gasoline stream from the carburetor throat, as shown. This mixture or emulsion of gasoline and air then travels downward to the idle discharge holes.

In normal operation, with the throttle closed to the correct throttle plate position for idling, as indicated by the dotted lines in

Fig. 120 (speed equivalent to from 5 to 7 miles per hour), the lower discharge hole only is subjected to intake manifold vacuum. The other idle discharge hole being above the throttle plate is not affected by this intake manifold vacuum and for this reason does not discharge any fuel with the throttle in this position. The lower idle discharge holes are provided with a means of adjustment (see fuel idle adjustment, Fig. 120).

Choke. The carburetor is provided with an unbalanced choke valve, into which has been incorporated an air bleeder or poppet valve. When the carburetor is choked, the throttle plate is auto-

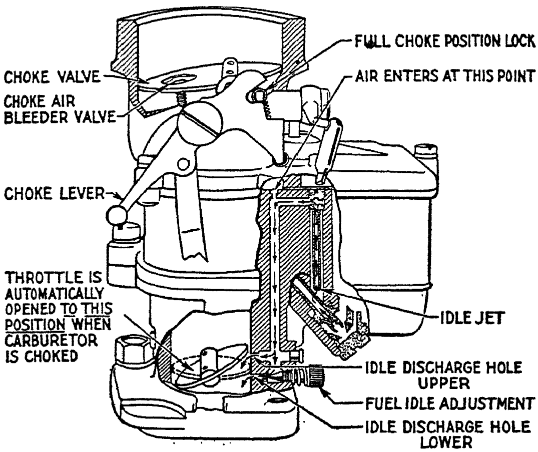


Fig. 120. Ford "V-8" Carburetor

matically open to the correct position for starting. For this reason it is neither necessary nor desirable for the operator to pull out the throttle button when starting. Fig. 120 illustrates the throttle plate position while the carburetor is choked. In this position the throttle plate is directly opposite the upper idle discharge hole and the stream of air passing around the throttle plate draws the fuel from both upper and lower discharge holes, whereas, in the normal idling position, as indicated by the dotted line, the fuel is drawn from the lower discharge hole only.

While the idle discharge holes both supply fuel when the carburetor is choked, the main discharge nozzle, Fig. 121, supplies the bulk of the fuel in full choke position. When the carburetor is fully

choked everything below the choke valve is subjected to intake manifold vacuum and all fuel discharge openings (except pump discharge nozzle) supply fuel. However, when the carburetor is not choked, the entire fuel supply for the engine for all speeds up to 25 miles per hour, is supplied from these idle discharge holes.

The choke butterfly valve has been mounted off-center so that, with the exception of the full choke position, the air flow through the carburetor throat has a tendency to push the choke valve open. However, this does not necessarily mean that the car can or should be continuously operated with the choke button in part choke posi-

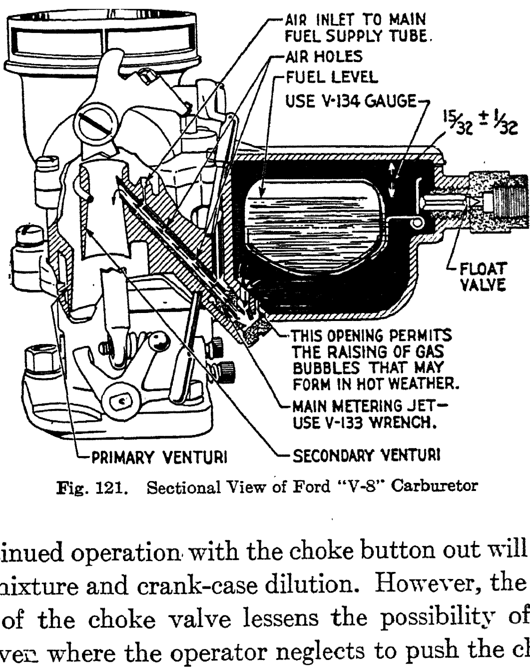


Fig. 121. Sectional View of Ford "V-8" Carburetor

tion. Continued operation with the choke button out will result in an over-rich mixture and crank-case dilution. However, the unbalanced mounting of the choke valve lessens the possibility of carburetor flooding, even where the operator neglects to push the choke button all the way in. In full choke position, the choke valve is held firmly in place and a lock is provided to prevent the air stream from opening the choke valve. To supply the necessary air to the carburetor, an air bleeder or poppet valve has been built into the choke plate which, as the vacuum in the carburetor throat increases, will open.

The opening of this poppet valve and the rush of air flowing through it makes considerable noise. This should attract the owner's

attention to the fact that the choke button is out and will continue to make this noise until the choke button is pushed all the way in or to a part choke position. The choke button should be pushed all the way in as soon as the engine has warmed up sufficiently to permit it to run smoothly on a normal mixture.

Main Fuel Supply. Starting at a speed of approximately 25 miles per hour, the main fuel supply discharge nozzle supplies all the fuel on up to approximately 75 miles per hour, at which time the by-pass or power jet also cuts in. The fuel, as was the case with the idling fuel supply, passes through the main metering jet. From this jet the fuel travels upward on an angle to the main discharge nozzle in the secondary venturi, as shown in Fig. 121. A slightly smaller jet, "40-9533C" is available for operations in high altitude.

As fuel is drawn from the main fuel supply tube, the idling fuel supply passages are emptied into this main fuel supply tube. As soon as the idling fuel supply tubes are emptied, the air entering at the air opening in the carburetor throat completely surrounds the main fuel supply tubes and is fed in small bubbles into the fuel stream. This feeding of small air bubbles into the fuel stream at several places forms an emulsion of the fuel, making the fuel lighter in weight and more responsive to throttle plate movement.

The venturi designated as the primary venturi, Fig. 121, increases the rate or speed of the air flow. The secondary venturi, opening as it does, above this restriction, and discharging below the point of greatest restriction in the primary venturi, takes full advantage of the unbalanced pressures, or the difference in pressure at the two ends of the secondary venturi, namely atmospheric pressure at the upper end, and the stepped-up vacuum at the lower end. In this way an even higher velocity for the air stream is obtained in the secondary venturi.

Float Level. As indicated in Fig. 121, the correct float level for these carburetors is 15/32 inch from the lower side of the float-bowl cover gasket. Since this carburetor is of the plain tube type, the float level is of more importance than it was on the air vane operated type of carburetor. However, a tolerance, either plus or minus, of 1/32 inch is permissible. The correct float level is measured from the lower side of the float-bowl cover gasket and should be not more than 1/2 inch and not less than 7/16 inch.

Accelerating Pump. An accelerating pump is provided to slightly enrich the mixture for rapid acceleration. Movement of either the foot or hand throttle causes movement of the accelerating pump. An accelerating pump inlet check valve is provided to prevent the accelerating pump from pumping the fuel back into the float bowl, Fig. 122. The pressure on the gasoline, exerted by the accelerating pump in its downward movement, opens the spring loaded valve directly beneath the spring loaded valve which is directly beneath the piston, and permits the gasoline to be forced out through the accelerating pump discharge tube and nozzle. However, a restriction has been provided to meter the gasoline and minimize the possibility of flooding.

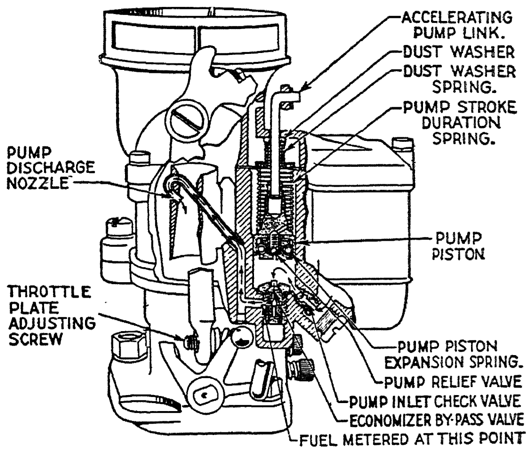


Fig. 122. Accelerating Pump of Ford "V-8" Carburetor

When the movement of the accelerating pump piston is too rapid to permit the flow of the gasoline through the restriction, the accelerating pump stroke duration spring is compressed. In this way the pressure exerted by the accelerating pump can never be in excess of the tension of the accelerating pump stroke duration spring.

When the throttle is completely open, the accelerating pump has moved to the bottom of its stroke, mechanically opening the economizer by-pass valve, at which time the economizer by-pass becomes a power jet, and the restriction already mentioned becomes the metering point for the flow of fuel. This power jet cuts in at about 75 miles per hour, or at a throttle position under heavy load con-

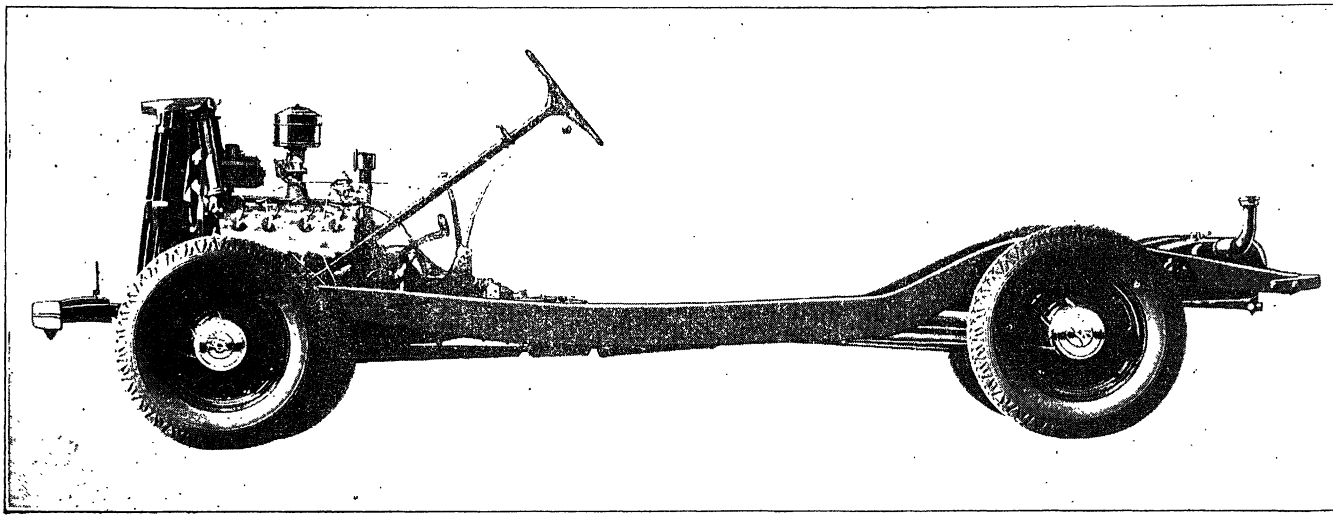
ditions, equivalent to 75 miles per hour on level roads with the passenger car.

Servicing. With the exception of the idle speed adjustment and the throttle-plate position adjustment for idling speeds, the carburetor is entirely automatic in action and will require no attention, other than the keeping of the various passage ways clear and free from obstruction. However, it is possible, with dirty gasoline, for small particles of dust to enter and become wedged in the various metering orifices, restricting the flow of gasoline and resulting in a lean gasoline-air mixture. The remedy for this condition is to remove various jets and force a stream of compressed air through the opening to remove any foreign bodies that may have lodged in them.

Both idle jets, both main fuel-supply jets and the power jet, as well as the check valve and all passageways, should be cleaned in this manner. The fuel pump screen and sediment chamber should also be cleaned. A suitable special socket wrench, "V-133," for the main fuel-supply jets has been developed. Never attempt to clean carburetor jets by running a wire through them. This practice will result in an enlarging of the fuel orifice, with the result that the carburetor mixture will be enriched and become unbalanced. A carburetor mixture either too rich or too lean, will result in high gasoline consumption. The carburetor is adjusted on each car before the car leaves the factory. However, the adjustment is set on the rich side so as to compensate for a slight stiffness in the new motor. For this reason the carburetor must be readjusted after the breaking-in period. This adjustment should be made on every new Ford car at the time of the 300-mile inspection.

Adjusting. The idle speed of the engine should be set by means of the throttle-plate adjusting screw, Fig. 122, to a speed equivalent to five miles an hour. For the idle mixture adjustment, have the engine well warmed up and be sure that there are no air leaks at the intake manifold, windshield wiper, and distributor vacuum connections. The idle speed should be set as outlined above. The fuel idle-adjustment needle valves, shown in Fig. 120, control the quantity of the gasoline-air mixture for low-speed operation. The turning out of the valves gives a richer mixture. The turning in of the valves gives a leaner mixture. Adjust one side of the carburetor at a time. Turn the valve in slowly until the engine begins to lag or run irregularly,

then slowly turn out until the engine begins to roll. Finally, turn in the adjustment again very slowly, just enough so that the engine runs smoothly for this speed. This adjusts the mixture for one side of the carburetor. Follow the same procedure for the other side of the carburetor. Ordinarily the correct adjustment will be with the fuel idle-adjustment screws both 5/8 to 3/4 of a turn open. It may be necessary, after making these adjustments, to reduce the engine speed back down to from five to seven miles per hour by means of the throttle-plate adjusting screw.



Ford "V-8" (Center-Poise Ride) Chassis

CARBURETORS

PART III

SCHEBLER CARBURETORS

Model "S." The discussion covering the fundamental principles of carburetion indicated that there are certain types of carburetors. The Schebler Model "S" is of the mechanical metering or measuring type. That is, it is designed to measure the gasoline used in relation to the amount of air, by mechanical means. The action

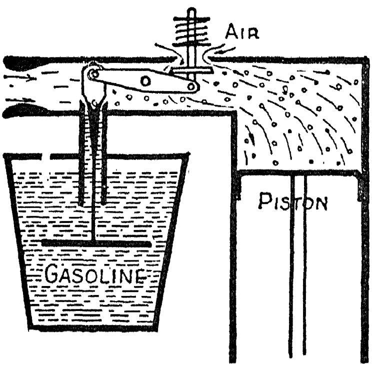


Fig. 123. Automatic Air Valve with Metering Pin and Dasher Attached

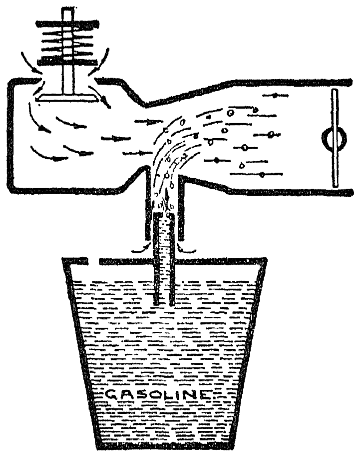


Fig. 124. The fixed air opening is so modified that it surrounds the fuel nozzle

is somewhat similar to that shown in Figs. 123 and 124, where we have an automatic air valve with metering pin and dashpot arrangement.

Many cars used the Model "S" Schebler carburetor of the auxiliary air-valve type, an external view of which is shown in Fig. 125. It has been standard equipment on a number of cars. Minor variations in the different models are employed. The description of the inbuilt characteristics of this carburetor is applicable to all models.

The Schebler Model "S" is provided with an accelerating pump, shown at *C* in Fig. 128. This pump is mounted in a well which is on a level with the gasoline in the carburetor body. This well is filled through the valves and the piston of the pump. When the throttle is open, the piston within the pump is raised and the gasoline in the well is lifted ahead of it, being forced upward across and into the venturi tube at its most constricted point and just above the main gasoline jet. This passage is illustrated in Fig. 128. Air rushing in through the fixed air opening picks up and atomizes

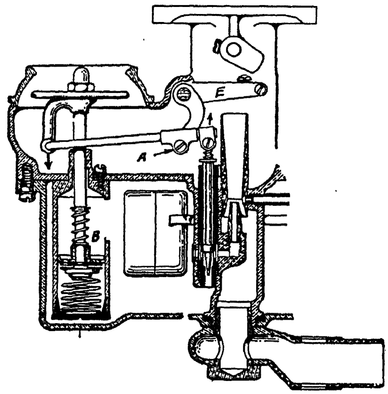


Fig. 127. Schebler Auxiliary Air-Valve Action

this fuel and it is mixed with the auxiliary air and carried on past the throttle into the engine to be used in the accelerating operation. In case too much gasoline is provided by the accelerating pump, that is, more than is needed for proper acceleration, the extra amount will pass through the overflow hole provided at *D* and thence be returned to the supply in the body of the carburetor so that it is not wasted. This overflow hole is adjusted for size and position when fitting a carburetor to an engine. By this arrangement just the proper amount of gasoline is sent through to care for the demands of acceleration.

A study of the several illustrations will show that the amount of gasoline flowing through the main jet is controlled by the position of the gasoline needle, that is, the gasoline needle is raised or lowered as the air valve is lowered or raised. The further the needle is raised

from its seat, the more the gasoline which may pass. In the case of average speeds on good roads the throttle is seldom full open, consequently the auxiliary air valve will not be at its greatest opening. The carburetor has been designed to provide good power and good fuel economy at average driving speeds. However, in the case of driving at top speed or driving when the last bit of power available is to be developed in any kind of going, then it is essential to enrich the mixture for that particular type of work. Under these conditions of wide-open throttle, a cam device has been provided on

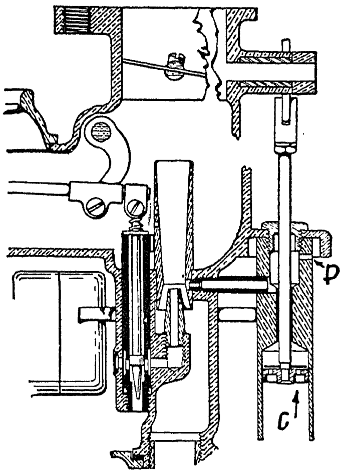


Fig. 128. Accelerating Pump and Well Is Used for Rapid Acceleration under Load

the end of the throttle shaft. This cam is so arranged as to strike an adjustable screw in the arm *E,* Fig. 129. This movement of parts throws *A* in toward the air valve and results in raising the needle valve a further distance from its seat, thus allowing the greater amount of gasoline required for full throttle opening to be provided.

A careful study of this device will show that practically every feature of adjustment required to meet any possible need provides for the gasoline needle being moved up or down. This same method is resorted to for securing a heavy charge of gasoline when starting a cold engine. No air choke is provided in the carburetor. The

usual dash-adjusting handle and wire known as the choke button is connected to the arm E. This is illustrated in Fig. 130, where it will be noted that E is shown in several positions and the connecting wire shows as both a heavy and dotted line, indicated by the arrow. When the dash adjustment is pulled out, the lever is pulled down. This rotates the lever in its shaft E in such a manner that A is thrown well over toward the air valve and the gasoline needle is raised from its seat, opening up the gasoline passage to its fullest size. Air passing through the fixed opening and the venturi will

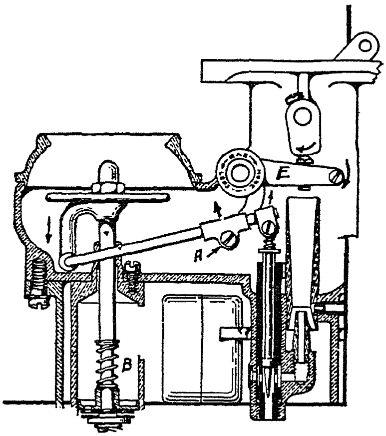


Fig. 129. Wide-Open Throttle Position for Hard Pulling and High Speed

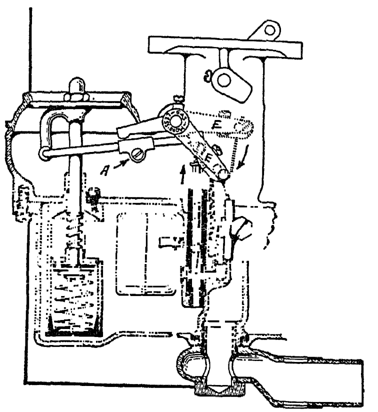


Fig. 130. Raising the Needle for Enriching the Fuel Mixture for Starting a Cold Engine on Schebler Model "S"

pick up sufficient gasoline to make starting easy, even with a cold motor. As the engine picks up speed and is warmed up, the dash adjustment should be returned to its normal position. A gradual return of the choker button will keep the engine operating while it is being warmed up.

Carburetor Adjustments. Having a thorough understanding of the principles involved and the working of the parts shown in the sectional views of this carburetor, the repair man is able to go about the adjustment of the carburetor in an intelligent fashion. A section of the exterior of the carburetor is illustrated in Fig. 131. There are several standard installations of the carburetor with

reference to the hook up of the choke wire. The one shown in Fig. 131 is different from the one shown in Fig. 130, but the principles involved are the same.

Idle Adjustment. The idle adjusting screw *A*, Fig. 131, is turned to the right for a lean mixture and to the left for a rich mixture. In order to check the idle adjustment, the motor should be warmed up thoroughly. Close the throttle and retard the spark all the way and then adjust the idle stop screw *B* so that the motor will idle not less than 5 miles per hour on the road. Then proceed to check up. Turn the idle adjusting screw *A* to the right slowly. Watch the motor fan at the same time and continue to turn it in this direction, which is leaning the mixture, until the fan falters or is not turning with a smooth constant motion. Just as soon as the

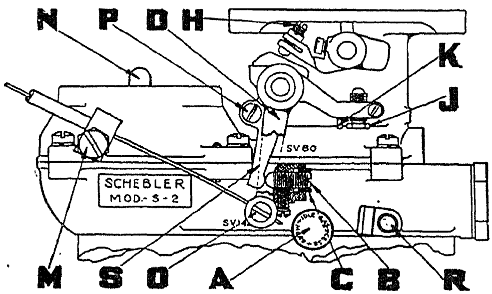


Fig. 131. Service Drawing of Schebler Model "S" Carburetor

fan is noticed to falter, stop turning the idle adjustment *A* to the right and turn it back or to the left, which is enriching the mixture. If the adjustment is made in the summer, turn the idle adjusting screw backward six notches or clicks. If the adjustment is made in the winter, enrich it eight or nine clicks.

Range Adjustment. This refers to the average driving range of speeds between 20 to 40 miles per hour and does not affect the acceleration or hill climbing with wide-open throttle. In order to make this adjustment, turn the range adjusting screw *B* to the left for the lean mixture and to the right for the rich mixture. A road test will show the performance of the car, and the range adjustment should be worked out so as to give a smooth running job between 20 to 40 miles per hour. This will assure good gasoline economy.

Power Adjustment. Extensive laboratory experimentation and road research shows that this carburetor gives the best mixture for maximum power on the hills or at high speeds when the power screw *J*, Fig. 131, is flush with the pin *K*. In high altitudes more power may be obtained by leaning up on the power mixture, that is, turn *J* to the left or counterclockwise from three to five turns. The higher the altitude, the greater the number of turns suggested.

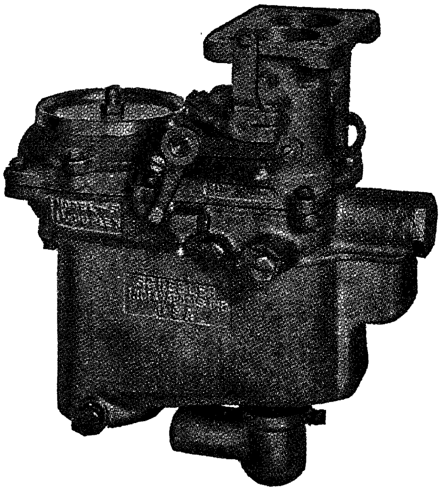


Fig. 132. Schebler Model "S" Duplex Carburetor

Accelerating Pump Adjustment. A small lever has been provided on the accelerating pump. This governs the amount of accelerating action. This lever should be in the raised position for winter, giving a greater amount of extra gas for acceleration. In the summer this lever should be pushed down because in summer not so much gasoline is required for quick acceleration.

Model "S" Duplex Carburetor. The general principles of design used for the single Model "S" are applicable to the duplex Model "S," Fig. 132. When starting a car equipped with this carburetor, the dash control is pulled all the way out. Next turn on the ignition switch, release the clutch, open the hand throttle about halfway, and step on the starting switch button. After the

motor starts to fire the dash control is immediately moved about half way back, or to a position where the engine will run smoothly and the car operate satisfactorily. As the engine is warmed up, the dash control is moved further in, in a gradual manner, until it is fully in. It is not necessary to use the dash control when starting a hot engine. If the engine should be flooded, open the throttle half way when cranking.

Carburetor Adjustments. *Idle Adjustment.* The duplex Model "S" is provided with two idle adjustments, shown at *A* and *E* in Fig. 133. Have the engine warm before making any adjustments. Both adjustments *A* and *E* turn to the right in order to make the mixture lean and to the left or counterclockwise to enrich the mixture. The duplex carburetor has two throttle openings into the

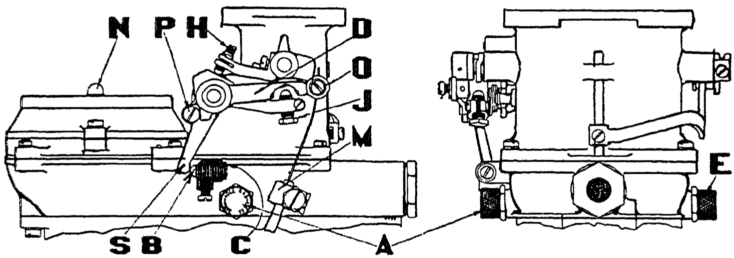


Fig. 133. Service Drawing of Schebler Model "S" Duplex Carburetor

manifold or two carburetor barrels. The throttle opening and idle adjustment next to the engine always control the four center cylinders of a straight eight—namely, cylinders 3-4-5-6. The throttle opening and idle adjustment of the carburetor which are on its outside or next to the hood of the car always govern the two front and two back cylinders—namely, 1-2-7-8. In order to effect the inside idle adjustment or the one next to the engine, disconnect the spark plug wires from cylinders 1-2-7-8, grounding them some place on the engine head so that they lie in contact with the cylinder head metal. This leaves the four center cylinders 3-4-5-6 operating. These are the ones supplied with gas from the inside barrel of the carburetor and the adjustment with the inside idle screw may proceed.

First run the idle adjustment screw H in a little ways in order to get a slightly faster idle speed. This is necessary when checking four cylinders at a time. Retard the spark and depress the air valve of the carburetor $\frac{1}{32}$ to $\frac{1}{16}$ inch. If the adjustment is lean on the four center cylinders, the engine will die immediately. If the adjustment is too rich, the engine will speed up. When the adjustment is just right, you should be able to depress the air valve $\frac{1}{32}$ to $\frac{1}{16}$ inch and the engine should continue to turn over for two or three revolutions and after that start to quit running.

When taking an outside idler adjustment, first remove the wires from the four cylinders 3-4-5-6, grounding them and then reinserting the wires on 1-2-7-8. The check-up proceeds just the same as for the four center cylinders.

When the two idle adjustments have been checked up satisfactorily, then the spark-plug wires are connected and a double check-up given by depressing the air valve of the carburetor the same as when checking four cylinders at a time. Before making the final check-up with all eight cylinders firing, the engine idling speed should be checked by setting the idle stop screw H so that the engine will drive the car from 5 to 6 miles per hour on the road. When making the final check by depressing the air valve, it may be found that the engine is a little too rich or a little too lean with the eight cylinders all firing. When attempting to correct this, turn the idle adjusting screws exactly the same amount in each case and turn them in the same direction so as to maintain comparative operation. Turn them but one, two, or three clicks at a time and test by depressing the air valve until proper operation is secured.

Range Adjustment. This adjustment is made by turning the range adjusting screw B to the left for a lean mixture or to the right for a rich mixture and will affect the driving range of the car between speeds of 20 to 40 miles per hour. The factory setting for this screw B is to have the head flush with the bushing C. If the range adjustment is changed, it will be found necessary to readjust the idle mixture.

Power Adjustment. This carburetor gives the best mixture for speed and maximum power on hills when the bottom of the head of the power screw J is setting so that it measures $\frac{7}{32}$ inch to the arm that holds screw J. The original factory setting is to have

the bottom of the head on the screw *J* flush with the bottom of the pin. In high altitudes it is always necessary to lean up the mixture in order to secure the best power. In this case, turning screw *J* to the left or counterclockwise from three to five turns is recommended. Turning this same screw to the right enriches the power mixture.

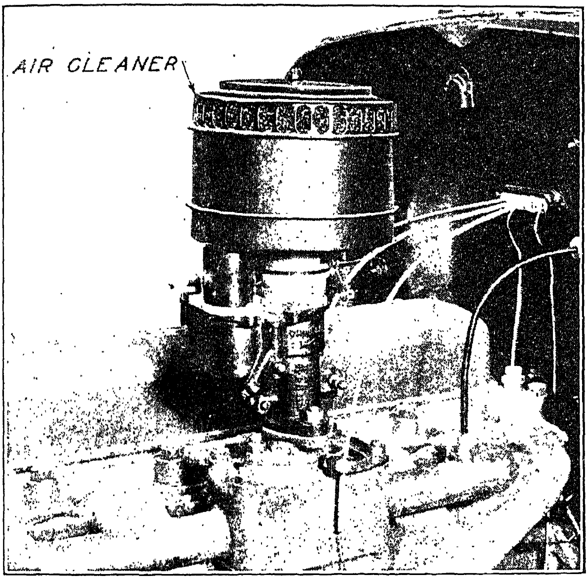


Fig. 134. Chevrolet Down-Draft Carburetor Mounted on Engine

CHEVROLET "SIX" DOWN-DRAFT CARBURETOR 1933 MODEL

A new Chevrolet carburetor, Fig. 134, is of the down-draft type, and before satisfactory adjustment can be made, there are certain steps which must be taken in the adjustment of every unit on the engine. Spark plug gaps should be correctly set, breaker points should be correctly adjusted, the ignition timing should be set according to manufacturers' instructions, and all valve clearances should be adjusted according to manufacturers' specifications.

The units on the engine having been taken care of, the adjustment of the carburetor can be proceeded with, providing that there

are no air leaks, and it is suggested that leaky intake manifold flange gaskets should be replaced with new ones and manifold bolts should be tightened.

The carburetor has but a single fuel-supply adjustment—to regulate the idle. First, set throttle lever adjusting screw so that motor runs approximately 350 revolutions per minute with spark fully retarded. Then set idle adjustment screw so that motor fires evenly without "loping" or stalling. The correct setting is one-half to one full turn open. Turning screw out gives a leaner mixture.

If a good idle cannot be obtained by these adjustments, remove low speed jet tube and clean thoroughly with compressed air. Examine soldered joint in tube for leaks and see that tube seats air-tight in body casting, top and bottom. If not, replace with a new tube of

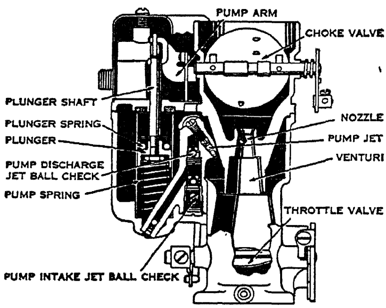


Fig. 135. Sectional View of Chevrolet Down-Draft Carburetor from Side

identical specification. Never change a low speed jet tube from one carburetor to another.

A correct idle is impossible unless spark plugs and tappets are set accurately as specified.

The accelerating pump, Fig. 135, is very efficient and gives maximum acceleration on about one-half of the quantity of fuel used by the common carburetor accelerating well. When the throttle is opened, it discharges a spray of fuel against the secondary venturi, insuring instant acceleration.

The pump arm is provided with three holes for the connector link, giving short, medium, and long strokes. The medium stroke is correct for ordinary temperatures and standard gasoline. The short stroke should be used in extremely hot climates, high altitudes, or

with high test fuel. The long stroke is for use in extremely cold climates.

It is important that the countershaft that operates the accelerating pump be lubricated at least once every 5,000 miles. To lubricate this shaft, remove screw attaching dust cover and fill threaded hole with a good grade of graphite grease.

Increased resistance on foot throttle indicates a clogged pump jet. Pump jet and ball check strainer should be removed and cleaned with compressed air, which, in many cases, will remove the dirt or lint. All jets and ball checks must be seated gasoline-tight.

Poor acceleration may be due to loose plunger, worn or damaged plunger leather, or sediment in pump cylinder. If necessary to re-

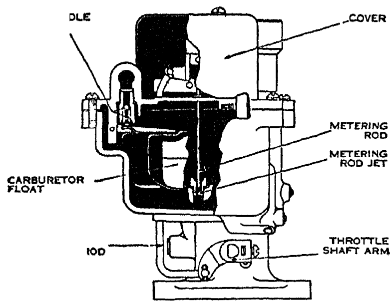


Fig. 136. Sectional View of Chevrolet Down-Draft Carburetor from Front

place plunger spring or leather, make certain that the nut inside the plunger cup is screwed down tight to avoid air leaks. Always use loading tool when replacing plunger in cylinder to avoid damage to leather.

If the carburetor loads up after considerable service, the float level should be checked. The float level should be $\frac{3}{8}$ inch, as shown in Fig. 136. Wear on lip of float lever will, in time, raise the float level.

To check the float level, remove dust cover. Disconnect metering rod, throttle connector rod, and plunger shaft. Take off float chamber cover and remove cork pump gasket from cover. Place steel scale on metal rim which holds pump gasket. Measure to nearest point of float.

To reset float, bend lip of float lever. A very slight bending is sufficient to change float level. Be sure lugs on float lever permit float to drop at least one-half inch from $\frac{3}{8}$-inch level, or to a point $\frac{7}{8}$ inch from float chamber cover. When replacing float chamber cover, be sure gasket seats air-tight against body.

In fuel-air ratio, each carburetor is calibrated to provide maximum power and mileage on standard gasoline in normal altitudes, and flow-tested to determine accurately the volume of air and fuel comprising the mixture. Leaner than standard fuel mixtures are obtainable by the use of special metering rods, as listed.

Great care must be used in changing metering rods, Fig. 136. Remove dust cover, take off pin spring, and turn rod one quarter turn counterclockwise to disengage it from pump arm. Be careful not to lose disc on rod. Insert new rod (with disc in place), holding it vertical to insure rod entering jet in float chamber. With throttle closed, turn rod one quarter turn to engage pin on pump arm. If lower end of rod is in place in jet, rod will engage pin on pump arm readily and hang vertical from pin. Any difficulty in re-assembling will indicate rod has not entered jet, in which case carburetor will not function. Replace pin spring and dust cover. Be sure lock washer is under head of attaching screw.

For years the carburetors for the Chevrolet models have been made by the Carter Carburetor Company. In every case these carburetors are calibrated, with reference to jet size, for the particular model engine to which they are fitted. While it is true that in the main the Chevrolet carburetors are similar, they are not interchangeable. It is difficult for the average mechanic to grasp the difference in car performance which is secured by changing jets. A minor difference in jet size will make major changes in performance and gasoline consumption economy. The mechanic who understands these points will use care when repairing carburetors.

Model "RJHO8." The International Chevrolet is equipped with a Model "RJHO8" multiple-jet plain-tube Carter carburetor of special design in which have been incorporated the improvements in the art of carburetion. Two views of this carburetor are shown in Fig. 137 with a list of the part names.

The conical type venturi choke insures excellent starting in cold weather and even firing during the warming-up period. This is ac-

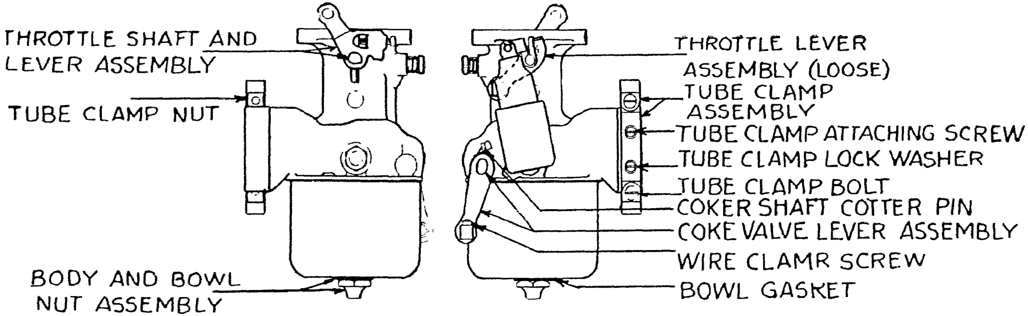


Fig. 137. External Construction and Adjustments of Chevrolet "Six" Carter Carburetor

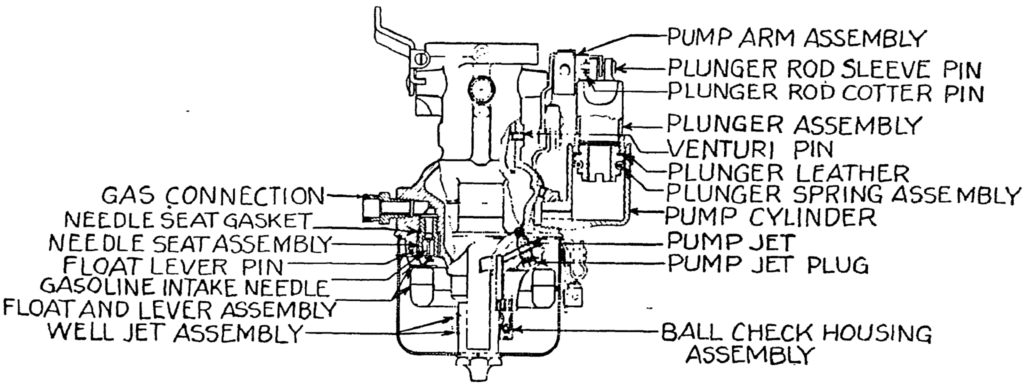


Fig. 138. Section through Float Chamber of the Chevrolet "Six" Carter

complished by regulating the main air opening at the venturi throat instead of at the carburetor air intake, as on the former models. By regulating the amount of air entering the venturi, the mixture ratio may be varied anywhere from 14 to 1 to 4 to 1 as desired, and due to the double-venturi construction, fuel is always thoroughly atomized as it leaves the standpipe and enters the mixing chamber.

Starting the Engine. When starting, the button on the instrument board marked "C" which operates the choke should be pulled out as far as possible. The button marked "G" which controls the throttle position should be pulled out slightly. When the engine starts, push the choker button in slowly a very short distance. The choker is not effective to any great extent in keeping a cold engine running unless the button is pulled nearly all the way out. If the engine runs at an excessive rate after starting, the throttle button "G" should be pushed in slightly till the proper speed is attained. If the engine gallops, the choke button should be pushed in slowly till the engine runs smoothly. As soon as the engine warms up enough to operate with the choke fully opened, it should be set in that position and at that time the throttle may be closed to idling position. During the warming-up period, it is recommended that the throttle valve be kept open to a point that will give an idle on level ground of from 12 to 15 miles per hour. This is the best position for starting the motor whether hot or cold and whether choke is used or not.

In extremely cold weather it is advisable, before pulling the choker, to depress the foot accelerator pedal three or four times, allowing the pedal to remain in the down position from one to two seconds each time it is depressed. This will operate the accelerating pump and spray gasoline into the intake manifold. Then set the dash throttle button to the correct position for starting and close the choke fully. When this procedure has been followed, very quick starting will be obtained, even in unusually cold weather. **Do not pump the throttle for starting when the engine is hot.**

Accelerating Pump. A specially designed accelerating pump, Fig. 138, providing long delayed action has been incorporated to aid in securing maximum acceleration and car performance. This pump is equipped with a ball-check inlet valve in the float chamber and a No. 75 jet, which discharges through the air chamber into the ven-

turi and will deliver a spray of gasoline for about two seconds after the throttle has been opened.

To secure high mileage, a fuel metering rod has been attached to the throttle valve which regulates the size of the vertical jet. This gives the equivalent of a small vertical jet for part throttle running, which insures the greatest economy at regular driving speeds, and a large vertical jet when the throttle is wide open, which gives maximum power for both speed and hill climbing. The mixture may be varied for different climates and fuels by changing the well jet which is located in the base of the body. Standard well jet is No. 57; richer jet is No. 56½; leaner jets are Nos. 58, 59, and 60. These jets may be used wherever a change in the mixture ratio is deemed necessary.

Acceleration of this carburetor is dependent to a great extent on the action of the pump and it is advisable to oil the plunger leather in the pump with a suitable oil whenever the car will be standing idle for any length of time. It is also necessary that the ball check seat properly, as any leak at this point will cause a loss of efficiency. If the pump jet becomes plugged up, the throttle will be hard to operate; in which case the pump jet should be removed and cleaned.

The carburetor is equipped with one adjustment only which is to regulate idling and low-speed mixture. This is an idle adjustment, Fig. 139, located opposite the edge of the throttle valve. Turning the adjustment screw in reduces the amount of air entering the carburetor at this point and gives a richer idling mixture. Turning it out gives a leaner mixture. The correct adjustment is from $\frac{5}{8}$ to $1\frac{1}{4}$ turns out. In securing a good idle on the Chevrolet "Six" engine, it is necessary to have the valves properly adjusted to a clearance of .008 inch on the exhaust and at least .006 inch on the intake, when the engine is thoroughly hot. Starting an engine and just warming it up does not get the engine hot enough to insure the proper valve clearance. If, after a hard drive, the engine does not idle smoothly, the valve clearance should be checked at that time and correct setting made. This will insure proper seating of valves at all times and will greatly increase the efficiency and life of the engine.

Carburetor Operation. The low-speed jet assembly, Fig. 139, supplies gasoline to the engine at idle engine speed and up to approximately 20 miles per hour, gasoline flowing through a drilled passage

the needle seat securely in place. In replacing, be sure all the parts are properly assembled—pointed end of needle in seat and rounded end projecting—and that all joints in the gasoline line are tight. Leaks in the gas line are both dangerous and expensive.

Flooding may also result from the float touching the bowl. This is caused either by the bowl being improperly seated at the top or by the float lever, Fig. 138, having been bent. If the float is rubbing, a bright spot will be found at the point of contact. This may be corrected by setting the float at its proper level or seating the bowl on the gasket in the carburetor body. If the float lever has been badly bent, a new float is the quickest and best remedy.

A float that has been punctured will cause the carburetor to flood. If the float is leaking, it will be evident from its weight and from the gasoline inside of it. In case of a leaking float, replacement with a new one is the only practical course. Soldering floats is rarely successful and often dangerous. The float and lever are soldered in a jig which insures a proper position when assembled in the carburetor at the factory. Be sure to set the float level properly when installing a new float.

Model "RTO8=13OS." The Carter carburetor used on the Chrysler Plymouth car is very similar to those used on some of the other cars in the same price class. The description given here will be helpful in such cases as well as for the direct application to the Plymouth job.

The Carter carburetor, Fig. 141, for the Chrysler Plymouth has been designed so as to give quick starting in any kind of weather and to insure steady running after starting, even with the engine cold. It is likewise designed to give efficiency as well as maximum speed and power on open throttle. Maximum economy of the carburetor is secured at approximately 20 miles per hour and the poorest economy is secured on wide-open throttle. The starting mixture is controlled by a single button on the instrument board. When this button is pulled out, the air passages are automatically closed through the venturi and the throttle is opened to correct position for starting. Air is then metered into the carburetor well and standpipe where it mingles with the gasoline and forms a spray of atomized fuel which is then drawn into the cylinders and readily ignited.

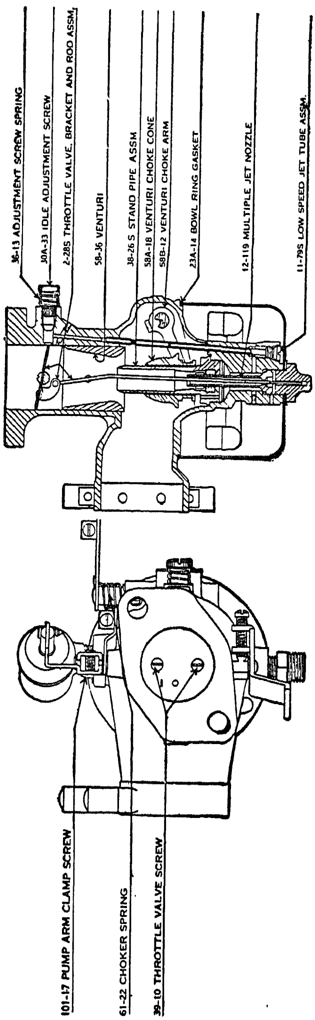


Fig. 139. Top View and Section through Venturi of the Chevrolet "Six" Carter

Leaks in the pump connections or dirt in the pump jet or ball check will interfere with its action. If the pump leather becomes dried out, put a few drops of castor oil on it. If the plunger is removed from the cylinder, a special tube must be used for reassembling, otherwise the leather will be damaged.

To start the engine, turn on the switch, pull the choker button out, pull the throttle button out slightly, and press the starter pedal. In extremely cold weather the engine should be allowed to run a few seconds with the choker in fully choked position. It should then be pushed in part way until the proper running mixture is secured.

Be sure the wire connecting the choker button on the dash and choker lever is adjusted properly so the choke will be wide open when the button is pushed in. This is normal running position.

The carburetor is calibrated to give the greatest efficiency when the engine is hot. Do not expect a cold engine to run properly with the choker pushed in. It will be found necessary to run the car, partly choked, longer in winter than in summer. The radiator should be partially covered to obtain the maximum efficiency in cold weather.

Carburetor Adjustment. The adjustment is properly set when the car leaves the factory and should not be changed until the engine is thoroughly run in. If necessary, the carburetor may then be readjusted. To adjust the idling mixture, retard the spark—open idle adjustment screw, Fig. 139, five-eighths to one and one-quarter turns or until the engine hits evenly without loading or missing. Turning this screw in gives a richer mixture.

The idle engine speed is regulated by the throttle lever adjusting screw. This acts as a stop for the throttle lever and prevents the throttle valve from closing too tight and allowing the engine to stop when the accelerator is released. With the throttle on the instrument board closed, set the throttle-lever adjusting screw so the engine will run 300 revolutions per minute. If the engine runs too fast, back the adjusting screw out; if too slow, turn in until the proper speed is obtained. The throttle adjusting screw is locked in the throttle lever by tension on the lugs through which the screw passes. If the screw becomes loose, these lugs should be bent slightly until the proper tension is again obtained.

Operation of Float. Gasoline, after passing through the needle seat, is admitted to the carburetor bowl by the gasoline intake needle and float. This mechanism maintains the correct level of fuel in the bowl. The float is properly set at the factory and should not be changed. The correct level is three-quarters inch from the top of the float to the machined surface of casting when the needle is closed, Fig. 140. This measurement should be taken on the side of the float opposite the gasoline intake needle. If, for any reason, the float lever must be reset, it may be done by bending the float-lever lip that comes in contact with the gasoline intake needle. Bending the lip up will lower the float level and bending it down will raise it. Only a slight bend is necessary to change the level.

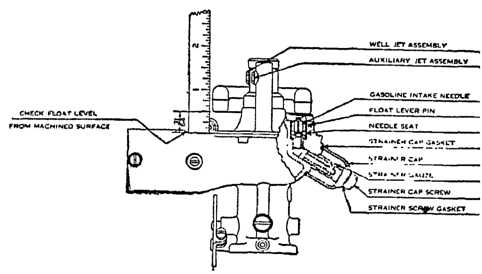


Fig. 140. Checking Float Level

Flooding. Flooding may be caused by dirt lodging between the needle and needle seat and can often be remedied by tapping the gasoline connection, the jar dislodging the dirt and allowing the needle to seat. If necessary to remove the needle and seat, it may be done by removing the bowl and float. Be careful in taking out the needle not to drop it, as it has a polished point which a scratch or dent would ruin. Wipe off the needle and wash the seat in gasoline. The needle may then be reseated, if necessary, by rotating it against the needle seat and tapping it lightly in the seat with a wooden handle of a hammer or screwdriver. Use wood so as not to mar the base of the needle which operates against the float lever lip. If the needle seat has to be removed, use a large bladed screwdriver and be sure to remove any burr that might be thrown up at the screw-driver slot as this might interfere with the proper action of the needle. In reassembling, be sure the gasket is not torn, then tighten

connecting the low-speed jet chamber with the carburetor well. At idle speed, gasoline is drawn through the low-speed jet and the idling port at the edge of the throttle valve. The idle adjustment screw regulates the amount of air entering this port. Backing out the adjusting screw admits more air and consequently makes the idling mixture leaner.

The vertical jet in the base of the multiple jet nozzle feeds gasoline direct to the nozzle chamber. The well jet in the side of the body feeds gasoline to the carburetor well. From this well a combination of gasoline and air is drawn into the nozzle chamber through the accelerating jets on the side of the nozzle, which intermingles with the fuel from the vertical jet, the combination forming a fine spray which is carried by the standpipe to the venturi or main air passage where it is absorbed by the incoming air, forming a mixture on which the engine operates. The jets on the side of the nozzle come into operation in direct proportion to the throttle position. The further the throttle is opened, the more jets are in operation. At wide-open throttle, all the jets are working and the engine is getting the maximum supply.

Starting Mixture. The starting mixture has been as carefully calibrated as the standard running mixture and when the engine is cranked over, the correct proportion of air commingles with a spray of fuel, forming a perfect starting mixture. Due to this design, which regulates the size of the main venturi air passage, the danger of over-choking the engine and of crank-case dilution is reduced to a minimum. While warming up the engine, set the choke to the position where the engine runs best, pushing it in to regular running position when the engine is thoroughly warm.

Accelerating Pump. The accelerating pump consists of an air chamber and fuel container which has been added to the accelerating well. The pump is actuated by the throttle lever, Fig. 137. When the throttle valve is closed, the gasoline is drawn into the pump cylinder through the ball-check housing assembly. The ball-check automatically closes when the throttle is opened, air is compressed in the plunger, and a fine spray of gasoline is discharged into the venturi through the pump jet. About two seconds is required to discharge the contents of the pump, supplying sufficient gas for accelerating under any and all conditions.

The interconnections between the choker and throttle levers automatically increase the engine idling speed to approximately 15 miles per hour during the period when the carburetor is partially choked. Naturally this advance in speed results in an engine which will keep running even though it is cold, thus eliminating the necessity of racing the cold engine before the oil in the crank case has had sufficient time to warm up and flow freely. An accelerating pump

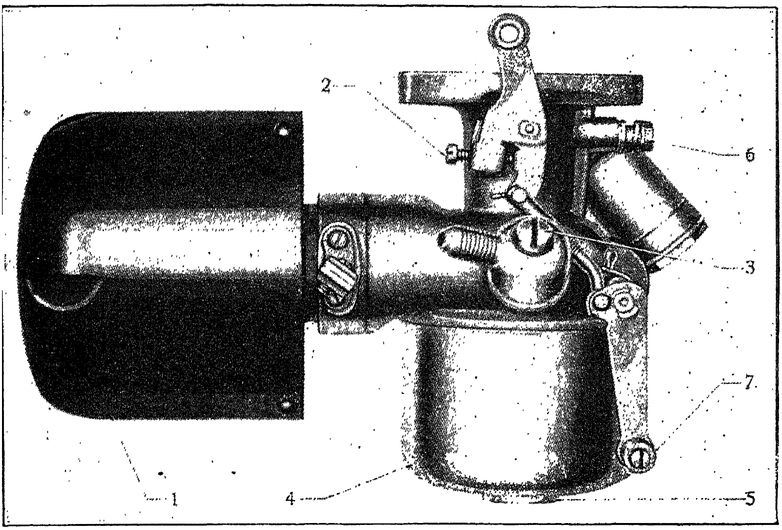


Fig. 141. Carter Carburetor and Air Cleaner

is used which consists of an air chamber and fuel container. The accelerating pump is actuated by means of a throttle lever. Only one adjustment is provided. This is for idling speed.

Carburetor Operation. The low-speed jet assembly supplies gasoline to the engine at the idling speed and up to approximately 18 miles per hour. Gasoline flows through a drilled passage, connecting the low-speed jet chamber with the carburetor well. At idle speed gasoline is drawn through the low-speed jet and the idling port at the edge of the throttle valve. The idling adjustment screw regulates the amount of air entering this port. Backing out the adjusting screw admits more air and makes the idling mixture leaner.

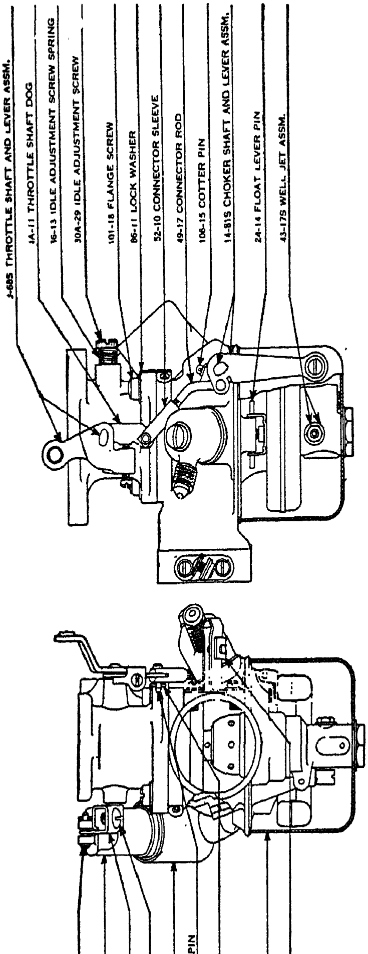


Fig. 142. Front and Side View of Chrysler-Plymouth Carburetor with Names of Parts

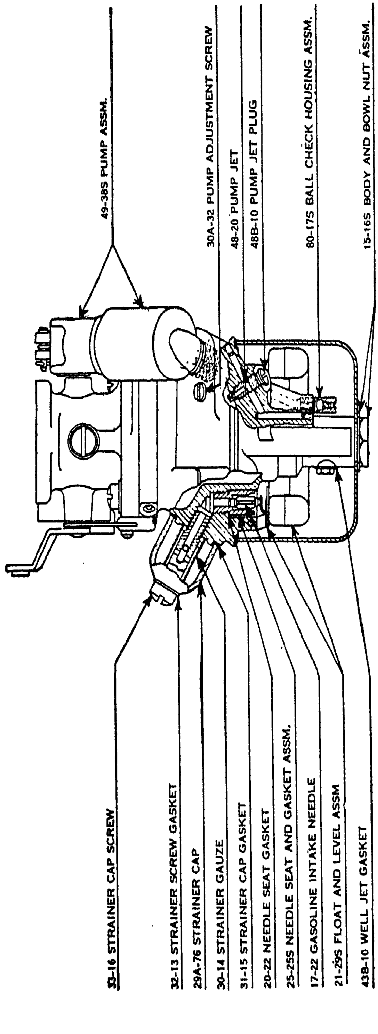


Fig. 143. Part Section View of Plymouth Carburetor

A vertical jet in the base of the multiple-jet nozzle feeds the gasoline direct to the nozzle chamber. The well jet in the side of the carburetor body supplies gasoline to the carburetor well. From this well a combination of gasoline and air is drawn into the nozzle chamber through the accelerating jets on the side of the nozzle, which intermingles with the gasoline from the vertical jet, thus forming a very fine spray which is carried by the standpipe to the venturi or main air passage where it is absorbed by the incoming air, forming a fuel mixture on which the engine operates efficiently. The jets on the side of the nozzle come into operation in direct proportion to the throttle opening. The further the throttle is opened, the more jets are in operation, thus metering the gasoline in proportion to the air. At wide open throttle, all the jets are working and the engine is getting a maximum fuel supply.

Carburetor Adjustments. *Choke.* The choke is hooked up in connection with the throttle lever, Fig. 142, so that when the engine is choked, the throttle is opening slightly. When warming up the engine, set the choke to a position where the engine runs best, pushing it in to regular running position as rapidly as the engine warms up. The action of choking the engine automatically increases the engine speed enough to prevent it stopping or stalling in traffic. If the driver is in the habit of pushing the choke all the way in as soon as the engine starts, it is likely the engine will stall in traffic when the engine is cold, with the result that the benefits of the design are lost to him. The choke is operated by the small button or knob on the instrument board.

Accelerating Pump. When the throttle valve is closed, the cylinder of the gasoline pump, Fig. 143, is filled with gasoline through a ball check in the housing assembly. This ball check automatically closes when the throttle is opened, air is compressed in the plunger, and a fine spray of gasoline is forced through the pump jet into the venturi tube. This gives what is termed a delayed action. Several seconds are required to discharge the contents of the pump, thus supplying sufficient gasoline for the accelerating period.

Air leaks in the pump connections or dirt in the pump jet or ball check naturally interfere with the accelerating action. If the pump leather becomes dried out, it should be treated with a few drops of castor oil. If the plunger is removed from the cylinder for

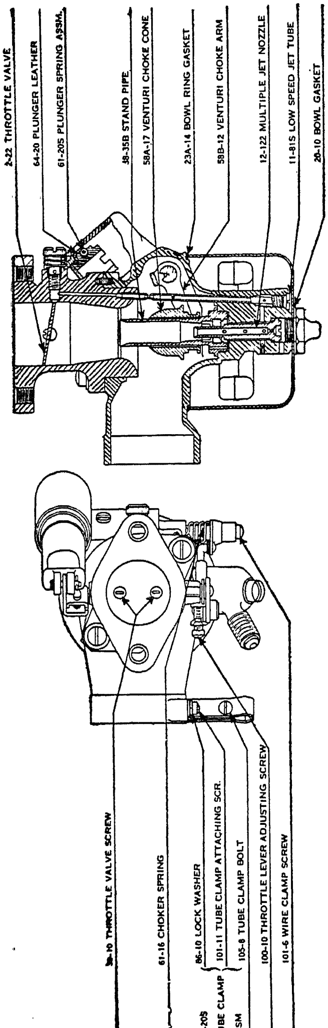


Fig. 144. Top View (left) and Sectional View (right) of Chrysler-Plymouth Carburetor

repairs, it will be necessary to use a special tube for reassembling it otherwise the leather may be damaged.

Idle Adjustment. It is never recommended that a carburetor be adjusted until the new car has been completely run in. If the car has been run in and operation is not satisfactory, the carburetor setting may be changed.

In order to adjust the idling mixture, the idling adjustment screw, Fig. 142, should be opened from one to one and five-eighths turns or until the engine hits evenly without loading or missing. Turning this screw in gives a richer mixture and turning it out gives a leaner mixture.

The pump adjustment screw, Fig. 143, is located in the body of the casting at the base of the pump cylinder and regulates the amount of gasoline sprayed into the venturi when the throttle is opened. Turning this screw in increases the amount of gasoline discharged through the pump jet.

The idle engine speed is regulated by the throttle-lever adjusting screw, Fig. 144. This acts as a positive stop for the throttle lever and prevents the throttle valve from closing too tight and allowing the engine to stop whenever the foot accelerator is released. When adjusting this screw, the first step is to set the hand throttle lever so as to secure an engine speed of approximately 300 revolutions per minute. If the engine runs too fast, it will be necessary to back out the adjusting screw. Make certain that the screw is locked in the lugs. If the screw becomes loose in the lug, it should be taken out and the lugs bent in slightly. When the screw is replaced it will be under sufficient tension to hold it.

Float Level Adjustment. The correct float level is $\frac{11}{16}$ inch from the top of the float to the machined surface of the casting when the needle is closed, Fig. 145. When resetting the float level, if this should be necessary, the work is done by bending the float lever lip which comes in contact with the gasoline intake needle. Bending the lip up will lower the float level and bending it down raises the gasoline level. Only a very slight bend is necessary.

Flooding may be caused by dirt lodging between the needle and the needle seat. The dirt can often be removed by tapping the strainer cap screw. The jar thus secured will allow the needle valve to seat. If the flooding is continuous, it will be necessary to

remove the intake needle. To do this remove the bowl and float. Carefully remove the needle, protecting the point, as it is easily damaged by dropping or scratching. Wipe off the needle and wash out the needle valve seat with gasoline. If it is found necessary to reseat the needle, turn it lightly in the seat, tapping it lightly with a wooden mallet or the wooden handle of a hammer or screwdriver. Use wood so as not to mar the base of the needle which rotates against the float lever lip. In case it is necessary to remove the needle valve seat, use a large wide-bladed screwdriver and then be very certain to remove any burr which may turn up at the screwdriver slot. When reassembling, be sure the gasket is smooth and in place, then tighten the needle valve seat securely in position.

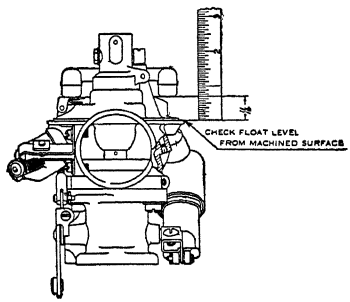


Fig. 145. Checking and Adjusting Chrysler-Plymouth Float Level

When replacing the parts, use utmost care to see that they are not damaged and that they go back in their original position.

Check all gasoline tubing connections and fuel pump connections to see that leaks are not occurring at these points. In some cases, flooding results from the float touching the bowl of the carburetor. This might be the case if the bowl were improperly seated at the top or if the float lever had been bent. When inspecting the float, if a bright spot shows, it will indicate that there is some point of contact. Correct this by seating the float at its proper level or by seating the bowl on the gasket in the carburetor body. If the float has been badly bent, a new float is the best remedy. Flooding may be due to a punctured needle. If the float is leaking, it will be evident from its weight and from the sound of gasoline in

it when shaken near the ear. In case of a faulty float, the only satisfactory repair is to replace it with a new one.

Cleaning the Carburetor. The most usual point requiring cleaning is the point at which the gasoline enters the carburetor through a fine wire gauze strainer which is located in the strainer cap. While this strainer will prevent the coarser particles of dirt from entering the carburetor, some of the very fine dirt, which may be dissolved, will be carried through it. The strainer should be cleaned each 2,000 miles. When doing this, remove the gasoline line, unscrew the strainer cap screw, and lift the strainer cap. Next remove the screen gauze and thoroughly clean it by washing it in gasoline and using an air jet to blow through it. Next clean the inside of the strainer cap thoroughly and reassemble, making certain that all parts are in their proper positions, neat and tight.

Dirt may sometimes get into the jets and cause the engine to operate unevenly or spit and backfire, indicating a lean mixture. If the operation of the engine indicates trouble of this sort, it is oftentimes possible to draw this dirt on through the jets if the car is taken on the street and operated at a speed of 25 to 30 miles per hour. When operating at this speed, hold the choker closed for about two seconds with the accelerator pushed to the floor board, which gives a wide-open throttle position. The momentum of the car, in gear, will carry the engine along until the operation has been completed. After the choker has been held closed for several seconds, it should be opened and the repair man should jiggle the accelerator, thus opening and closing the throttle. In a few more seconds the engine should begin to operate evenly. This operation will require but a few minutes to try. If it does not result in clearing out the obstruction within the carburetor, it will be necessary to remove the carburetor and disassemble. When disassembling the carburetor, utmost care is necessary when removing the jets. Make sure that the screwdriver is of the proper size, otherwise the jets, which are screwed in very snugly at the factory, will have their screwdriver slots destroyed and then the job cannot be disassembled or repaired. When cleaning out the jets it must be remembered that they are constructed from brass, which is a comparatively soft metal. If the size of the jet openings is enlarged, the efficiency of the carburetor will be destroyed.

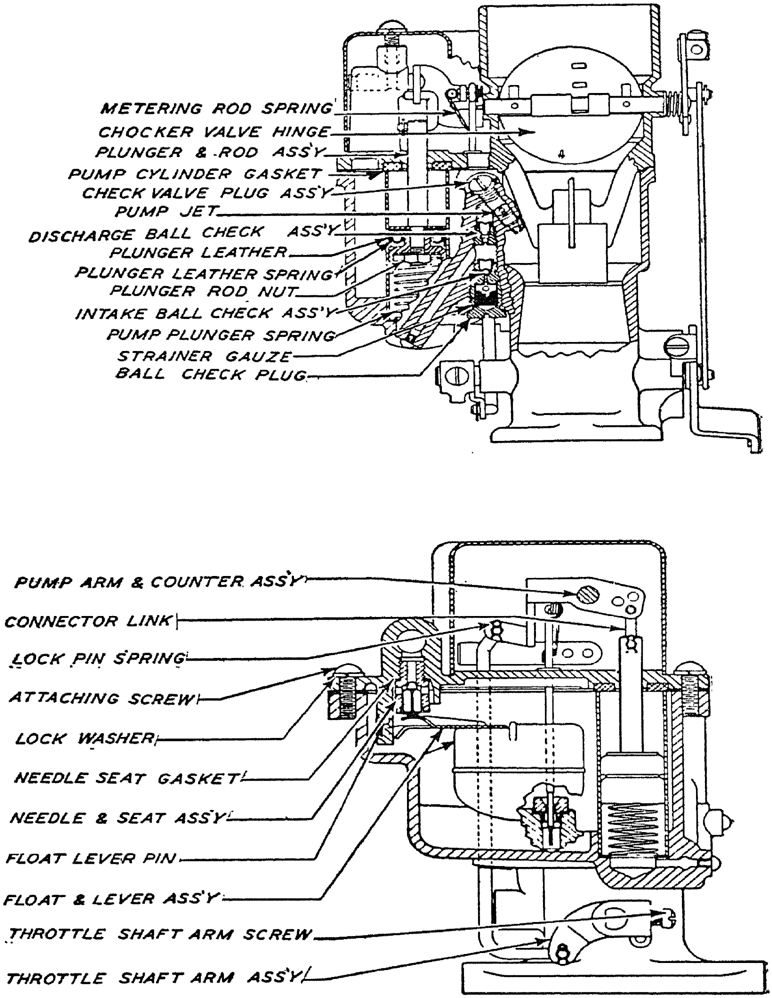


Fig. 146. Pontiac Carburetor in Sectional Views

PONTIAC CARBURETOR

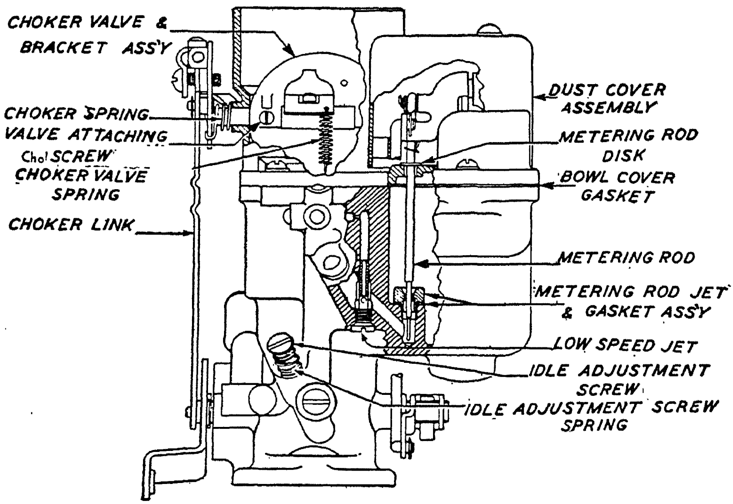
Model "283-S." The Model "283-S" Carter triple venturi downdraft carburetor, Fig. 146, is used on the 1934 Pontiac straight eight. It employs an economizer, metering rod, and a low pressure type accelerating pump with adjustable stroke. The carburetor is only one of the factors which affect performance and fuel economy. Good practice demands that this unit be untouched until after inspection has been made to determine whether trouble exists in some other unit. See that the gasoline lines are clear; that the fuel pump is properly supplying fuel; that there are no leaks at manifolds; that the ignition system is in proper condition; and that there is even compression in all cylinders with tappets correctly adjusted.

Carburetor Adjustment. A single fuel supply adjustment is provided to regulate the idle. First, set the throttle lever adjusting screw so that the engine runs approximately 360 revolutions per minute or 6 miles per hour idle in high gear on level road. Then set idle adjustment screw, Fig. 147, so that the engine fires evenly without loping or stalling. The correct setting is one-half to one full turn open. Turning the screw in gives a leaner mixture, and vice versa.

Accelerating Pump. When the throttle is opened, it discharges a spray of fuel against the secondary venturi, insuring instant acceleration. The pump arm is provided with three holes for the connector link, giving short, medium, and long strokes. Medium stroke is correct for ordinary temperatures and standard gasoline. Short stroke should be used in extremely hot climates, high altitudes, or with high test fuel. The long stroke is for use in extremely cold climates.

It is important that the countershaft operating the accelerating pump be lubricated at least once every 5,000 miles. To lubricate this shaft, remove the screw attaching the dust cover and fill the threaded hole with a good grade of graphite grease. Increased resistance on the foot throttle indicates a clogged pump jet. The pump jet and ball check strainer should be removed and cleaned with compressed air which, in many cases, will remove the dirt or lint. All jets and ball checks must be seated gasoline-tight.

Poor acceleration may be due to loose plunger, worn or damaged plunger leather, or sediment in the pump cylinder. If necessary to replace plunger spring or leather, make certain that the nut inside the plunger cup is screwed down tight to avoid air leaks.



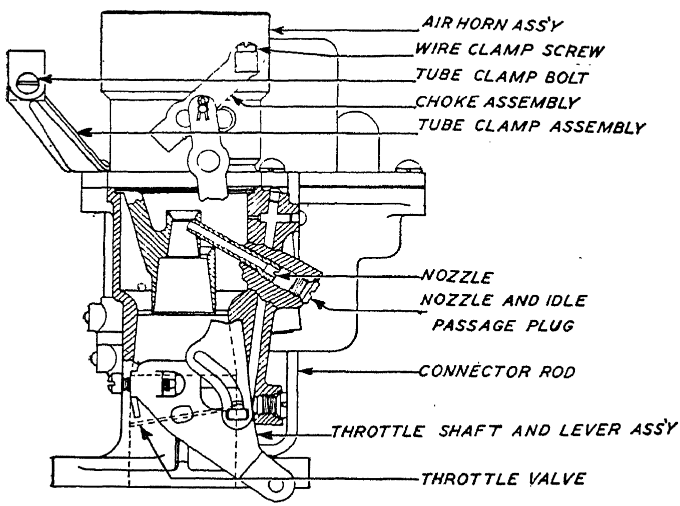


Fig. 147. Pontiac Carburetor in Sectional Views

Float Level. If the carburetor loads up after considerable service, the float level should be checked. Wear on the lip of the float lever will raise the float level. To check the float level, remove the dust cover; disconnect the metering rod, throttle connector rod, and plunger shaft; take off the float chamber cover and remove the cork pump gasket from the cover; place the steel scale on the metal rim which holds the pump gasket and measure to the nearest point of float. This dimension should be $\frac{3}{8}$ inch, as shown in Fig. 148.

To reset the float, bend the lip of the float lever very slightly, which is sufficient to change the float level. Be sure the lugs on the float lever permit the float to drop at least one-half inch from $\frac{3}{8}$ inch level, or to a point $\frac{7}{8}$ inch from the float chamber cover when the float bowl is empty. When replacing the float chamber cover, be sure the gasket seals air-tight against the body.

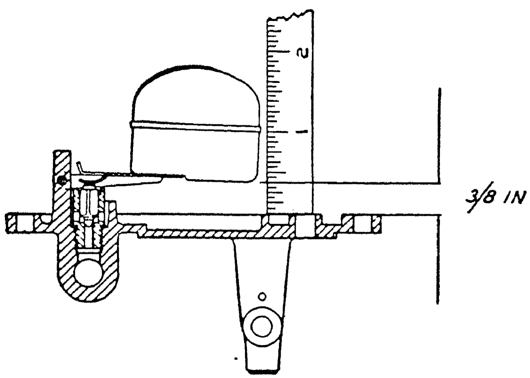


Fig. 148. Adjusting Float Level

Heat Control. Manifolds have been designed to utilize the exhaust gases of the engine to insure complete vaporization and a consequent minimum consumption of fuel. The heat control assembly is fully automatic in its operation, being controlled by a coiled thermostatic spring mounted on the forward side of the heat control section of the exhaust manifold. A counterweight under spring tension is mounted on the rear end of the heat control valve shaft to permit uniform and proper opening and closing of the valve during engine operation. This means that during the warm-up period or initial starting all the possible heat is deflected to and around the intake

manifold at the time when it is most required. Due to thermostatic action, as the engine warms up, heat is gradually directed away from the intake manifold by the heat control valve, so that, as high driving speeds are reached, a minimum amount of heat is retained and all exhaust gases are passed direct to the exhaust pipe and muffler.

The heat control valve and path of exhaust gases are shown in Fig. 149. To provide proper operation of the heat control valve at all temperatures, it must be accurately set and it will then require only seasonal adjustments, winter or summer. With the coiled

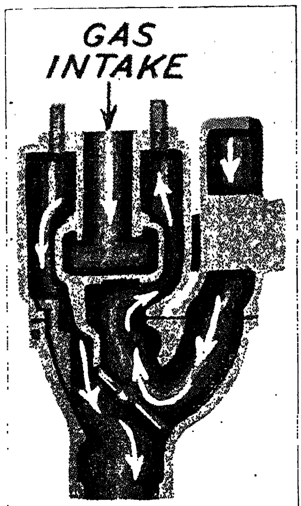


Fig. 149. Heat Control Valve, Sectional View

thermostat spring connected to the valve shaft and with the engine cold, the clamp screw must be made tight to prevent slippage of the counterweight lever on the shaft. The screw should be parallel with the flat on the shaft.

To make seasonal adjustment, the thermostat cover must be assembled with the ear marked "top" on the upper screw in the exhaust outlet, Fig. 150. The shutter on the thermostat cover must be set so that the blades are in the "open" position in winter and in the "closed" position in summer. The open position permits cold air to blow through the shutter and cool the thermostat in winter. The

shutter is not completely closed in the summer position, but should be rotated as far as the stop will allow. For winter use, the thermostat stud should be in the third hole from the left, as viewed from the front of the engine, and for summer use, in the second hole from the left. Four holes in all are provided for the stud, one at either side of the two holes mentioned above. This gives a greater range for extreme temperatures. The warm-up period is prolonged by increasing the tension of the thermostat coil spring and shortened by decreasing the tension.

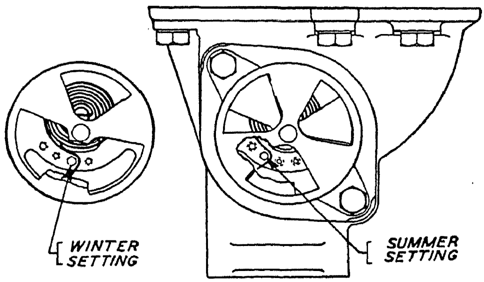


Fig. 150. Seasonal Adjustment
Thermostat cover must be assembled with ear marked "top" on upper screw in exhaust outlet.
Shutter on thermostat cover is to be adjusted "open" in winter and "closed" in summer. Shutter is not completely closed in summer position but should be rotated as far as stop will allow.
The two end holes in the row of four are provided to meet extreme conditions of temperature. If necessary to prolong the warm-up period in extremely cold weather the pin may be placed in the position giving greatest tension to the thermostat, and to decrease the warm-up, set in the position for least tension.

1934 CHEVROLET CARBURETOR

The down-draft carburetor contributes to the smooth, quiet operation and power of the Chevrolet valve-in-head engine. Down draft, as its name implies, eliminates the necessity of lifting air and gasoline from the carburetor, thus improving the breathing ability of the intake system without affecting its flexibility. This carburetor, Fig. 151, embodies a principle which employs three venturis, one located above, and two below the level of the fuel in the float chamber. This triple venturi has the effect of increasing the suction on the first or primary venturi, causing the nozzle to start delivering fuel at very

low air speeds. The nozzle enters the primary venturi at an angle, discharging upwardly against the air stream. This angle secures an even flow of correctly proportioned and finely atomized fuel.

The fuel thus atomized in the primary venturi is kept centrally located in the air stream by the surrounding blanket of air passing into the second venturi, and this process is repeated by the air in the main venturi. By this means, the fuel is carried to the cylinders in a more perfectly atomized condition. This insulated atomization results in increased smoothness of operation at both low and high speeds. The mixture quality is controlled by a metering rod which

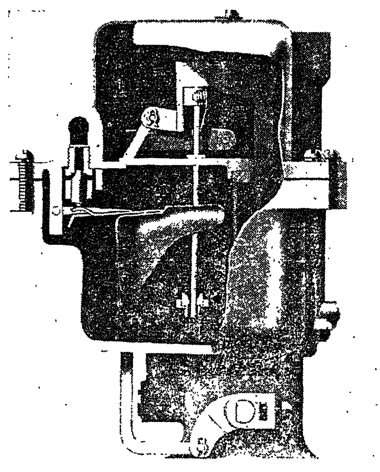


Fig. 151. Carburetor Metering Rod and Jet

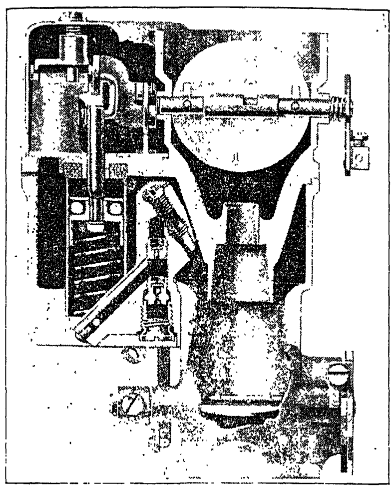


Fig. 152. Carburetor Choke Valve and Accelerating Pump

operates within the metering rod jet, Fig. 151, and is operated by the throttle lever. There are two steps of different diameters on this metering rod. The larger diameter, or economy step, controls the fuel flow to about seven-eighths throttle when the smaller diameter, or power step, becomes effective, giving full power for either high speed or hard low speed pulling. By this simple means, both maximum power and greater economy can be had without changing the carburetor adjustment.

The choke consists of a butterfly valve, hinged in the center, one-half being spring controlled, Fig. 152. When fully choked, a

trigger lock limits the movement of the spring controlled valve, admitting the right amount of air when the motor fires to keep the motor running. As soon as the choke is released slightly, the hinged half of the valve opens and acts as an air valve during the warming up period. This prevents overloading and produces a smooth running mixture with a cold motor. The accelerating pump, Fig. 152, is of the pneumatic type and consists of a cylinder with a plunger containing an air bell and two check valves, one on the inlet and one on the outlet side. The upward movement of the plunger, when the throttle is closed, draws a small metered quantity of fuel into the bottom of the cylinder. The slightest opening of the throttle causes

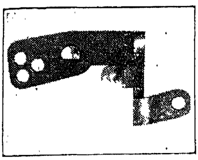


Fig. 153. Accelerating Pump Plunger Arm

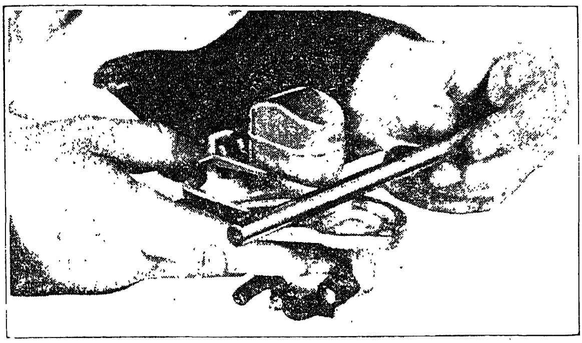


Fig. 154. Checking Carburetor Float Level

an immediate discharge through a jet pointing downward into the main venturi.

Carburetor Adjustment. There are two adjustments on the carburetor, one for idling mixture, and the other for idling speed. Both of these adjustments should be made together, having the engine thoroughly warmed up. To adjust the idling mixture proceed as follows: Open the idle adjusting screw from $\frac{1}{2}$ to 1 turn open; let the engine idle; try turning the screw both ways from this position until the best setting is made. To adjust for idling speed, proceed as follows: With the hand throttle on the instrument panel closed, set the throttle lever stop screw so that the engine runs at approximately 400 revolutions per minute. If the engine runs too fast, back the screw out, and if it runs too slow, turn it until the proper speed is obtained.

Accelerating Pump Adjustment. The lever which operates the accelerating pump plunger arm, Fig. 153, is provided with three adjustments or settings. Medium stroke is the correct setting for ordinary temperatures and standard gasoline. Short stroke is for use in extremely hot climates, at high altitudes, or with high test fuel. The long stroke is for use in extremely cold climates. To set this pump arm lever, it is necessary to remove the cover from the top of the accelerating pump. When this cover is removed, the countershaft that operates the accelerating pump should be lubricated with graphite grease. To do this, fill the cover screw hole with the grease.

Float Level. The float level, $\frac{3}{8}$ inch, should be maintained for the best economy. This measurement should be taken on the side of the float, opposite the gasoline intake needle and measured from the top of the float to the machined surface of the bowl cover, with the gasket removed. An easy method of measuring this level is by

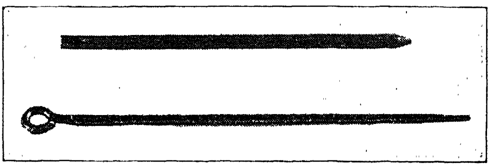


Fig. 155. Metering Rod

the use of a $\frac{3}{8}$-inch round drill rod, as shown in Fig. 154. If the float level must be reset, bend the lip that comes into contact with the gasoline intake needle. When the lip is bent up, it will lower the float level, and if bent down it will raise it. Only a slight bend is necessary to change the float level.

Metering Rods. The metering rod, which controls the amount of gasoline passing through the jet, can be changed to meet the various climatic, fuel, and driving conditions. These various sizes, which are listed below, are available through the parts warehouses and are marked as listed, Fig. 155. Production metering rods, which are the standard size, are not marked.

CADILLAC CARBURETOR

The Cadillac carburetors, Fig. 156, are of the expanding air vane type, and are simple in construction with no thermostats. They have

only one adjustment which controls the mixture by varying the flow of fuel rather than the air.

The carburetors used on the various Cadillac models are of the same construction, but differ in size and other minor details. The 370-D and 452-D carburetors are identical with the exception of the

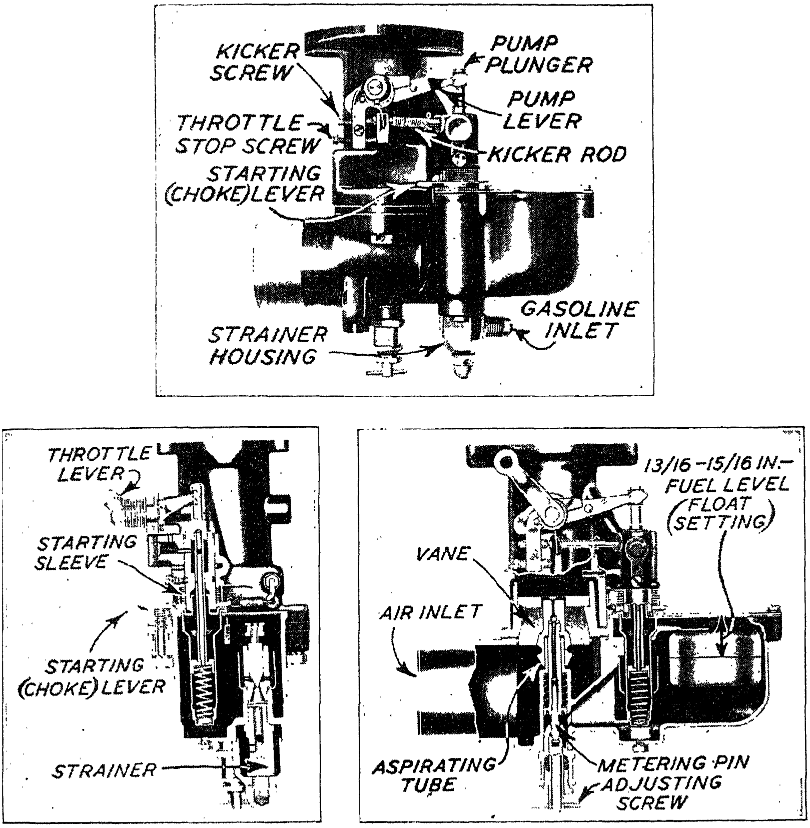


Fig. 156. Cadillac Carburetor and Sectional Views

size of the metering pin. Right and left carburetors also differ in the control levers. The name plate marking identifies the type of carburetor; 370-D carburetors are Type R-13 and L-13; 452-D carburetors are Type R-14 and L-14. Otherwise the carburetors on these car models are fully interchangeable. The carburetor consists chiefly of two units, the main metering unit and the auxiliary unit.

Main Metering Unit. The main metering unit consists of a pair of air valves or vanes, hinged at their lower ends and opening upward to admit air to the mixing chamber. These vanes have fingers which engage a control aspirating tube, raising it as the vanes open. This aspirating tube is attached to a spring loaded hollow stem and piston working in a dashpot, the piston carrying the fuel metering orifice in its lower end. An adjustable tapered metering pin projects into this orifice.

Auxiliary Unit. The auxiliary unit combines an auxiliary power jet, an accelerating pump, and a priming passage for starting. The operation of the auxiliary unit is controlled by the registering of ports in the starting sleeve, which line up with passages in the throttle body. The starting sleeve rotates with the starting lever (choke lever) and the pump plunger and piston move downward as the throttle is opened. For normal running, the fuel enters the carburetor float bowl through the strainer and float needle valve, and it is maintained at constant level by the float and float needle valve.

Air. Air enters the carburetor through the air inlet and lifts the vanes as it passes upwards into the mixing chamber. The weight of these vanes, combined with the pressure exerted by the dashpot spring, causes a partial vacuum to exist in the mixing chamber, which draws fuel from the aspirating tube. The quantity of the fuel flowing is controlled by the tapered metering pin. At idle speed, the vanes are almost closed and the metering pin almost fills the orifice in the air valve piston. As the vanes rise to admit more air, the aspirating tube also rises and the metering orifice becomes larger, due to the taper on the metering pin. This combination maintains the correct ratio of fuel and air for average running.

Power. For maximum power at any speed, a richer mixture is required than is necessary for part throttle running. The power jet supplies the required extra fuel, while the throttle is held open beyond the point which would give a road speed of about 60 miles per hour. At this throttle position, the pump plunger has traveled downward and has shut off the air vent to the power jet, therefore, the suction on the discharge nozzle draws fuel from the pump cylinder up through the hollow stem of the pump plunger and through the power jet into the mixing chamber. At part throttle positions below 60 miles per hour road speed, this power jet does not supply fuel since it is vented

to the outside air through the air vent hole in the upper part of the starting sleeve. The quantity of fuel drawn from the power jet is controlled by the air bleed hole in the pump plunger stem.

Acceleration. For rapid acceleration, it is necessary to supply a momentarily rich mixture. This extra fuel is supplied by means of the accelerating pump. A rapid opening of the throttle causes a rapid downward movement of the pump plunger and piston, forcing fuel up through the hollow stem of the pump plunger and out through the discharge nozzle into the mixing chamber. The fuel in the pump cylinder cannot escape back into the float chamber because of the check valve in the bottom of the pump cylinder. In general, for steady driving conditions up to 60 miles per hour on level roads, the fuel is all supplied from the aspirating tube. When the throttle is opened suddenly, an additional charge of fuel is supplied from the accelerating pump, and if the throttle is held open as for hard pulling or high speed, extra fuel continues to flow from the pump discharge nozzle through the power jet.

Choke. All Cadillac cars are equipped with a semi-automatic choke, which permits a more efficient choking of the carburetor during the warming up period than is possible with a manual choke control. When the engine is cold before starting, the semi-automatic choke is automatically in the choke position. The manual choke on the instrument panel should be used as necessary when starting a cold engine, but it should be pushed in immediately after the engine starts. The purpose of the semi-automatic choke is to keep the engine from stalling and to prevent popping back into the carburetor before the engine has reached the proper operating temperature. As the engine warms up, the thermostat starts to open the choke so that when the engine has reached its correct operating temperature, the semi-automatic choke is in full open position.

AUTOMATIC CARBURETOR CHOKE

A Stromberg carburetor and an automobile intake manifold in phantom view with the Stromberg automatic choke in bold relief are shown in Fig. 157. This automatic choke is designed to eliminate entirely the need of hand choking an automobile when starting or otherwise operating it. Its operation is wholly governed by vacuum

and the heat of the engine, and the part played by each of these should be continually kept in mind.

The action of the choke is very quick, being vacuum controlled. Its opening operation is controlled by the heat, which allows the choke valve to open the correct amount during the warming-up period of the engine.

The thermostat, which appears in the nature of a coiled spring on the face of the device, returns the choke valve in the carburetor

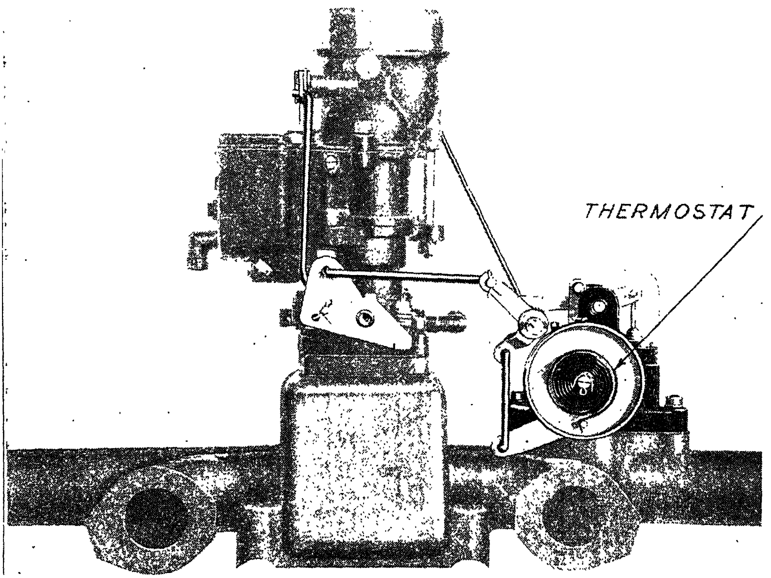


Fig. 157. Stromberg Automatic Carburetor Choke

to closed position when the thermostat reaches a temperature of 70 degrees Fahrenheit.

The choke valve is closed during the cranking of the engine and is held so by the locking of a roller against a cam. When the engine fires and a manifold vacuum is created, a vacuum piston within the device is pulled part way down, thus unlocking the cam and the roller.

As the engine starts to operate smoothly, an even vacuum will be present and the piston within the device will travel its remaining

distance, operating another lever off of the cam, which opens the choke a predetermined distance against the tension of the thermostat spring.

The distance between the lever and the cam is an adjustable one. When the motor has reached a water temperature of 120 degrees Fahrenheit, the choke valve should be in a wide-open position. If it should not be found in such a position, adjustment should be made to compensate for it.

BENDIX STROMBERG AUTOMATIC CHOKE CONTROL

General Description. The Stromberg automatic choke control is a device that eliminates all methods of hand operated chokes. Its operation is wholly governed by vacuum and heat of the engine, which makes it positive acting under any conditions. It acts quicker than any choke can be operated by hand and allows the carburetor choke valve to open the correct amount during the warming up period of the engine.

Principle of Operation. This principle of operation is shown in diagrams 1, 2, 3, and 4, Fig. 158. The thermostat *A*, Fig. 158, returns the choke valve in the carburetor to closed position when the thermostat reaches a temperature of 70 degrees. The choke valve is closed during the cranking of the engine and held so by the locking of linkage *K*. When the engine fires and a manifold vacuum is created, the vacuum piston *B* is pulled down, and through the lever *D* unlocks linkage *K*. From then on, the choke valve opens against the tension of the thermostat *A*. When the motor has reached a water temperature of 120 degrees, the choke valve should be in wide open position.

Adjustments. The choke is not a delicate instrument, but, when servicing, it should be given the same consideration as any fine part of the engine. For adjusting the automatic choke control for any reason whatsoever, it can be quickly and accurately done by following very carefully the procedure outlined below:

1. Remove the automatic choke from the motor by disassembling the carburetor choke rod and accelerator rod connected to the safety release lever.

2. Under any conditions, the thermostat *A* should be allowed to cool or warm until it has reached a temperature of 70 degrees. This is very important and, if the car has been running, it is necessary to allow the automatic choke to stand long enough to cool off, or on the other hand, if the place or garage where the choke is to be adjusted

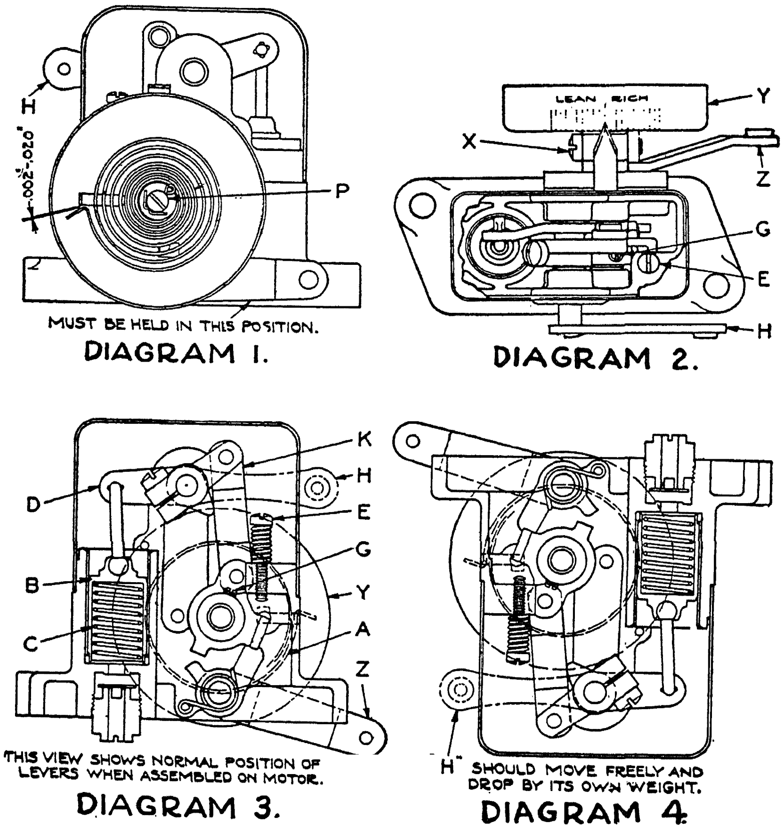


Fig. 158. Bendix Automatic Choke Control

is colder than 70 degrees, the choke should be taken into a room of normal temperature.

3. During the entire check of the automatic choke, it is necessary to hold the safety release lever *Z* in horizontal position (even with the base), diagram 2, Fig. 158.

4. Unhook the thermostat *A* from the hook, set case *Y* five notches lean for the Olds F-32 and eight notches lean for the Olds L-32 (this will differ for various installations), and with the lever *H* in the uppermost position, there should be from .002 inch to .020 inch space between the hook and prong of the case. If this space needs to be adjusted, loosen screw *G* and turn shaft *P*. Fasten the screw *G* securely, observing that the thermostat does not rub against the case *Y*.

5. Hold the automatic choke in an inverted position. Lift up the lever *H* and let it drop. It must drop freely and by its own weight. Observe if linkage *K* comes back to lock position.

6. Assemble the thermostat on the prong, returning the case *Y* to zero position.

7. With this setting, lever *H* should catch in the choke closed position but should yield to a light pressure. Revolve case *Y* one-quarter turn (prong will be under pointer). With this tension, lever *H* should resist a light pressure, but it should yield to a tap of the hand. There should be a noticeable difference in the settings. If the catch of lever *H* is to be changed, adjust screw *E*. Turning screw *E* IN or clockwise, will cause lever *H* to offer less resistance, turning screw *E* OUT will increase the catch of lever *H* in the choke closed position.

8. Fasten screw *X* securely.

9. Piston *B* should work freely and should show no signs of sticking in any position. When piston *B* is pushed down, it should unlock linkage *K*.

10. Assemble the cover on the body. Before tightening the screw, make certain that the cover plate is not assembled so that it will bind against the shaft.

11. Assemble the choke control on the manifold, fastening screws securely.

12. Assemble connecting rod between choke control and carburetor so that there is only .006 inch backlash between levers. If it is necessary to adjust, loosen the clamp screw of the carburetor choke lever. Assemble the accelerator rod in lever *Z*.

13. Assemble the air cleaner so that it will not interfere with the carburetor choke lever.

14. Make a final check on your work and test the job.

1934 OLDSMOBILE 8 STROMBERG MODEL "H" AUTOMATIC CHOKE CONTROL

Principle of Operation. The thermostat *A*, referring again to Fig. 158, returns the choke valve in the carburetor to closed position when the thermostat reaches a temperature of 70 degrees. With this action the vacuum piston *B* is raised so that it is ready for a start. Lever *F* comes to rest against adjustment screw *E*. The choke valve is closed during the cranking of the engine and held so by the locking action of linkage *K*. When the engine fires and a manifold vacuum is created, vacuum piston *B* is pulled down. With it lever *D* is moved down which forces the choke valve to open a predetermined amount. Lever *H* is on the same shaft as lever *D*, and is connected to the choke valve by a connecting rod.

Adjustments. This type of automatic choke control requires very little attention. It is only necessary that all operating linkage moves freely and does not bind in any position. This is particularly necessary with the connecting rod between the carburetor and the choke control. Freeness of the rod should be checked in both the wide open and closed positions. With the lever of the automatic choke in the uppermost position and the choke valve closed, there should be only .006 inch backlash in the hook-up. If necessary to reset, it can be done by moving the carburetor choke lever to give the desired amount.

The adjustment screw *E* is set at the factory to give the desired amount of locking linkage *K* and it should not be necessary to tamper with this adjustment. Therefore, the only adjustment that should be checked is the thermostat. When checking this, it is necessary that the thermostat be allowed to cool or warm until it has reached a temperature of 70 degrees. This is very important and, if the car has been running, it is necessary to allow the automatic choke to stand long enough to cool off, or, on the other hand, if the place or garage where the choke is to be adjusted is colder than 70 degrees, the choke should be taken into a room of normal temperature.

When the thermostat has reached 70 degrees, remove the hook from the prong of the thermostat case. Revolve the case so that the zero marking is directly in line with the thermostat pointer. In this position, the end of the hook should come flush with the prong. If

this space needs to be adjusted, loosen the set screw in lever *F*, and move the thermostat to the desired position. Fasten the set screw securely. Place the hook of the thermostat on the prong and revolve the case three notches rich.

When servicing the automatic choke control, it is also important that the gasket between the base and the intake manifold is in good condition, and that the choke attaching screws are screwed down evenly so that there is no leakage around the channel leading to the vacuum piston.

Engine Hot or Cold—Slow Idle. The slow and fast idle, Fig. 159, on the eight cylinder carburetor is controlled through the

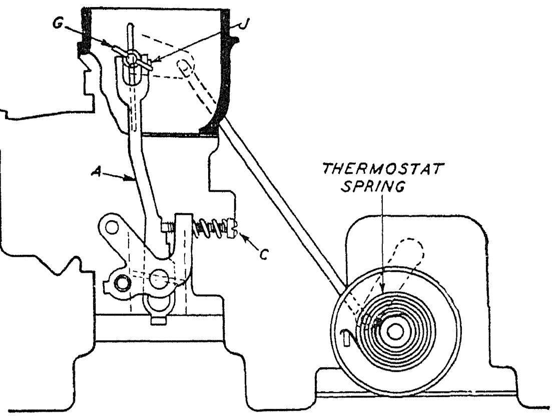


Fig. 159. Slow Idle Control

action of arm *A* which determines the location of idle adjusting screw *C*, on the three steps of the arm. The choke valve in the carburetor is hooked up to the thermostat, which regulates the opening and closing of the choke valve, according to the temperature of the engine, or the thermostat spring. Pin *G* is fastened to the choke valve shaft and revolves with it when the choke either opens or closes. Arm *A* is moved up by pin *G*, bearing against the lug *J*, located on arm *A*. Arm *A* will fall of its own weight when pin *G* drops, or the choke valve is opened.

As the engine becomes cold, the thermostat of the choke control gradually gains tension and will tend to close the choke valve. Pin *G* revolves with the choke shaft and lifts with it arm *A* until its move-

ment is stopped by the notch on the arm *A*, coming in contact with the adjustment screw *C*.

Engine Cold—Fast Idle. As soon as the starter button is depressed, the pick-up on the starter rod partially opens the throttle,

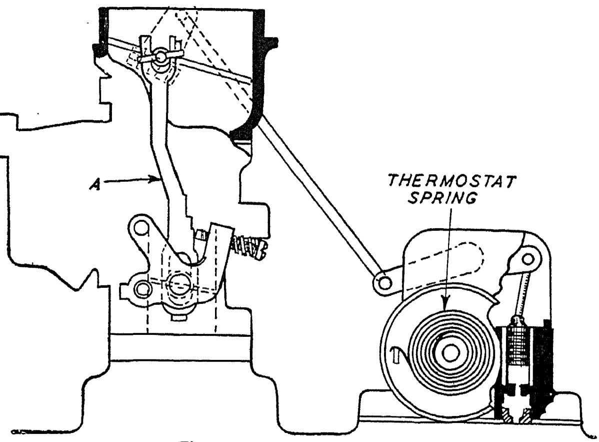


Fig. 160. Fast Idle Control

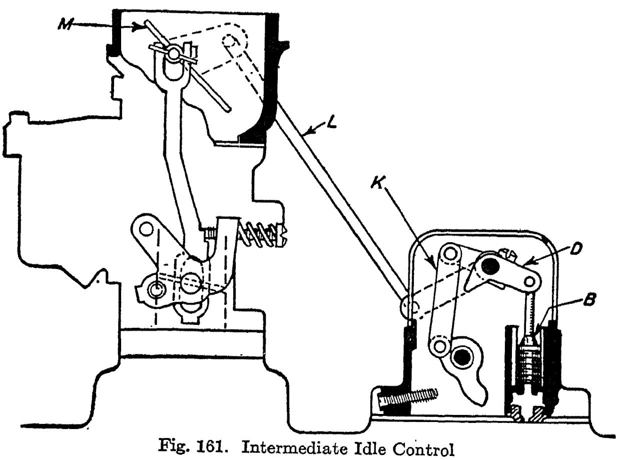


Fig. 161. Intermediate Idle Control

at which time the arm *A*, is freed and the tension of the thermostat spring entirely closes the choke valve. The screw then rests on the stop shown in Fig. 160, on the extreme fast idle position. During the cranking of the engine the carburetor and choke control remain in the position as shown in Fig. 160.

Engine Warm—Intermediate Idle. As soon as the engine starts to fire, the manifold vacuum pulls the piston *B* down, Fig. 161. Lever *D* is forced down and breaks linkage *K* to move rod *L*. This partially opens the carburetor choke valve *M* to admit air for proper running mixture. As the engine warms up, the choke valve is opened entirely by the inrushing air as the tension of the thermostat becomes weakened from the heat of the exhaust manifold.

Engine Flooded—Throttle Wide Open. If, for any reason, the engine should become loaded by excessive cranking, and fail to start, it can be cleaned out by holding the accelerator pedal in wide open position and allowing the starter to turn over the engine a few

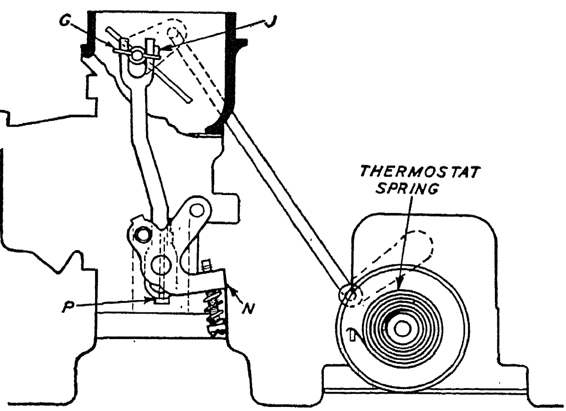


Fig. 162. Relieving Flooded Engine

times. Opening the throttle wide, revolves the lever *N*, Fig. 162, so that it contacts with ear *P* on the bottom of arm *A*, which forces the arm down, bringing lug *J* in contact with pin *G*.

DE SOTO AUTOMATIC CHOKE

An automatic choking device is provided which operates the carburetor choke when starting and during the warm-up period. A control button is provided on the instrument panel for emergency use, in case the engine becomes loaded while starting. If the engine does not start readily, press the button "in" and hold while continuing to crank the engine. This allows the choke to open slightly and avoids flooding.

To adjust the automatic choke, remove the air cleaner from the carburetor, and the cover from the automatic choke. Next, clamp the adjusting tool in place, so the pin in the tool enters and lines up the two holes in the armature and magnet core of the unit, locking the armature in the closed position. Then loosen the arm on the choke unit operating shaft and while holding the lever down inside the unit, to remove backlash, set the choke blade in the closed position and tighten the clamp screw in the choke operating arm.

Before removing the setting tool, check the choke for backlash by grasping the choke rod and pushing lightly back and forth. If there is no evidence of backlash, adjustment is correct.

CARBURETOR TROUBLES AND REPAIRS

Operation Troubles. The basis of good engine operation has been given as good compression. The basis for economical operation is good carburetion, and it cannot be obtained unless the symptoms of incorrect carburetion, carburetor troubles, and their effect on engine operation, are known and understood. The following is a summary of troubles due to carburetors and their action on engine operation and their cures.

Spitting Back through the Carburetor on Sudden Acceleration. This may be caused by two things. (1) Weak mixture, due to incorrect adjustment of the carburetor. The cure is to readjust the carburetor. (2) Air leaks in the intake manifold or stoppage in the gasoline supply. Air leaks in the intake system can be in two or three places. One at the intake-manifold joint can be tested in the following manner. Take an oil can and fill it with gasoline and squirt the gasoline around the joints. If the engine runs better after this treatment, the trouble is at these joints. Air will also leak in at the intake valves if they are worn, which will necessitate new guides being installed. If the mixture must be made very rich to have the engine run smoothly, it will often indicate worn intake-valve guides. If the carburetor butterfly-valve shaft is badly worn in the bushing, a great deal of air will be drawn in that will upset any kind of adjustment that may be made with the carburetor adjustments, and the only cure is the fitting of new shaft and bushings to the carburetor. If on trying the adjustments no change can be noticed, it is a good plan to examine the butterfly

shaft and bushings. Stoppage of the gasoline supply can be caused by the strainer being clogged up with dirt or lint. To cure this trouble it will be necessary to take the instrument apart and clean every part thoroughly.

Uneven Running at High Speeds with Black Smoke Coming from the Exhaust. This indicates too rich a mixture and the engine will tend to run in the following manner: There will be a series of explosions followed by a period of rest. These periods follow each other quickly with every cylinder firing during the time the explosions are taking place. It is termed "galloping." If more air makes the engine run evenly, readjust the carburetor.

In systems where vacuum tanks are used, it often happens that the valves inside the vacuum tank will fail to operate correctly so that the tank will fill up and raw gasoline will be drawn through the suction pipe into the intake manifold and a very rich mixture will result. In testing, disconnect the suction pipe and place a finger over the opening in the intake manifold. If the engine runs better, then the vacuum tank must be overhauled.

In the case of the cork float type of carburetor, the float may be soaked with gasoline and is too heavy to shut off the gasoline at the correct level, causing too rich a mixture. Dry the float and give it a thin coating of shellac, being careful not to make the float too heavy. A metal float may be punctured and filled with gasoline. This will make it too heavy to function correctly, causing the carburetor to flood. It is best to install a new float in this case. A temporary repair may be made by immersing the float in very hot water. This will vaporize the gasoline inside the float and the hole can be found. The hole can then be covered with a very thin layer of solder. Care should be taken that the float is not thrown out of balance or it will stick in the float chamber. Too rich a mixture can also be caused by the choke valve sticking or not working correctly due to some mechanical trouble such as a broken choke wire, which should be renewed.

Missing at Low Speeds. This trouble is usually caused by air leaks. Another cause is the dilution of the charge by exhaust or burnt gases. If the exhaust valve leaks, some of the exhaust gases will be drawn back into the cylinder as the piston goes down on the suction stroke. The low speed or idling speed fuel charge is

very small, and a very small quantity of burnt gas drawn back into the cylinder will dilute the charge and cause missing at low speeds. The dilution of this charge will often cause missing even up to a speed of 30 miles per hour. The trouble is not exactly a miss but rather a weak explosion, which makes it seem like a miss and causes the engine to run unevenly.

Missing at High Speeds. This trouble may be caused by stoppage in the gasoline supply or by valves holding open. Water in the gasoline may also be a cause. The supply system should be cleaned out and the valve clearance checked. If there is water in the gasoline, the carburetor should be drained. The presence of water will be shown by little bubbles separating themselves from the gasoline. The gasoline should be poured back into the tank through a chamois skin.

No Power on a Hill Climb. When a car runs well on the level but will not pull on coming to a hill, it is an indication of a stoppage in the gasoline supply. The cure for this has been given. In high altitudes an engine seems to lose power due to the compression volume being less than in low altitudes.

Engine Overheats. Too rich a mixture may be the cause and the cure for this has been given. In high altitudes an engine will heat because of the lower boiling point of water as well as because the air is less dense which causes the mixture to be richer.

Engine Starts and Then Stops. This may be caused by dirt in the jet. The engine will start but as quick as the suction comes particles of dirt will be drawn into the jet opening and gasoline will be prevented from passing through the opening. The carburetor should be cleaned out. This same trouble may be caused by the gasoline level being too low.

Engine Will Not Start. See that the gasoline is getting through to the carburetor—if there is any in the tank—by raising the needle valve and seeing if the carburetor floods or the gasoline runs over the top of the float bowl. If there is gasoline in the carburetor, the trouble must be in the ignition system, unless the adjustment of the carburetor is entirely out of order. When starting the engine, excessive use of the choke should be avoided because it floods the engine with raw gasoline and makes it still harder to start. It also causes a great deal of carbon to form as well as causing crank-case

dilution. It will also wash the oil off of the cylinder walls and gives a chance for the cylinders to score. In very hot weather the engine will lack pep or operate sluggishly. If the heater pipe is disconnected or some of the heat shut off from the carburetor, the operation of the engine will be greatly improved. It is a good plan to crank the engine in cold weather with the switch in the "off" position so that a charge of gas can be drawn into the cylinder before the switch is turned on. The clutch pedal should also be pushed down because the starter will not have to pull against the heavy oil in the transmission and it will give the spark a better chance to fire the cold gasoline. After the engine has started, the mixture should be set so that the engine will run evenly. The engine should be allowed to warm up before the car is driven. This not only prevents the intake of raw gasoline, but also gives the oil a chance to warm up and start circulating.

Misfiring or Backfiring in Muffler When Descending a Hill. When coasting down a hill with the gears in mesh, the trouble of backfiring in the muffler is often experienced. This trouble is also caused by charge dilution. If the exhaust valves do not seat properly, some of the exhaust or burnt gases will be drawn back into the cylinder and dilute the charge. The throttle being closed, the charge is very small and the least little dilution upsets the explosion and makes it a very slow burning mixture. A weak spark will also cause this firing in the muffler.

Mechanical Troubles and Cures. The height of the gasoline is an important item in the operation of the carburetor. The correct level for the gasoline in the jet is on a level with the top or with a bead of gasoline on the top of the jet. The level is controlled by the length of the needle above or below the collar on the needle valve, Fig. 163. If the length of the needle is increased below the collar, the valve will shut off earlier and the level will be lower. If the length of the needle is decreased below the collar, the valve will shut later and the level will be higher. The result of too high a level will be flooding, while too low will cause hard starting or no starting at all. Fig. 164 shows how the level of the gasoline can be tested. In most carburetors the body of the device can be removed and the jet exposed to view. Take a small tank and place it up high so that there will be a good deal of pressure behind the

gasoline. Clamp the carburetor in a vice so that it is level. Connect the tank with the carburetor and allow the liquid to flow into the float bowl. If the gasoline runs over, the level is too high and the length of the needle below the collar should be increased.

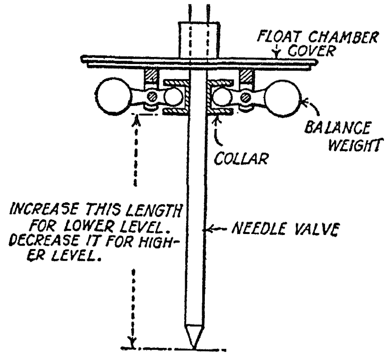


Fig. 163. Gasoline Level Control

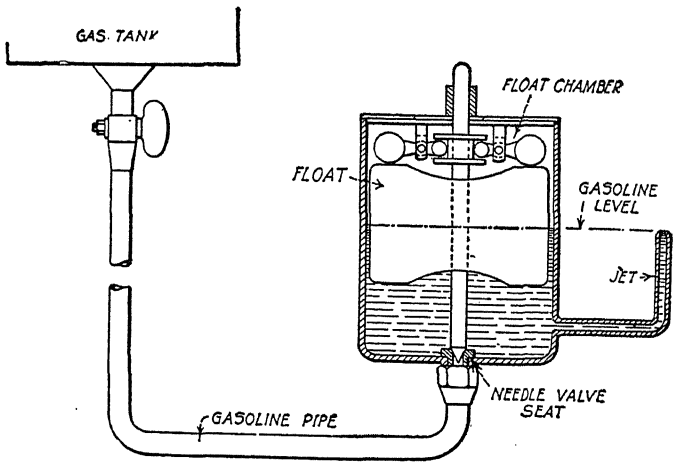


Fig. 164. Testing the Level of Gasoline

If the liquid cannot be seen in the top of the jet, the level is too low and the length of the needle below the collar should be decreased. In decreasing the length of the needle, the point of the valve should not be damaged or the needle will never seat. In the cork or hinged-

type of float, the hinge of the float must be bent or altered to correct the gasoline level.

Another cause of flooding is a worn needle valve and seat. If the needle is not badly grooved, it can be lightly ground to fit the seat again by the use of ground glass and oil. The best and cheapest plan is to install a new valve and seat. The needle valve seat is screwed into the carburetor body at the bottom of the float bowl. Particles of dirt will lodge on the valve seat and prevent the proper closing of the valve, causing a gasoline leak. If the body of the carburetor is wet, it does not always indicate that there is a leak because with the heavy fuel in use today, there is always dampness around the body which dries when the engine is started. The body remains dry as long as the engine is warm.

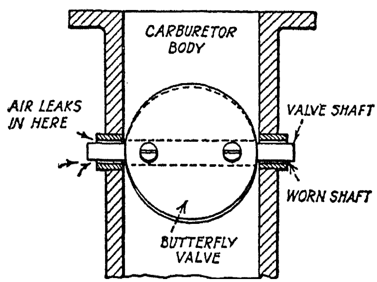


Fig. 165. Worn Butterfly Shaft and Bushings

Worn Butterfly Shaft and Bushings. Fig. 165 shows this condition and the only cure is to install new shaft and bushings. This trouble will upset any adjustment that is made on the carburetor because a great deal of air can be drawn into the manifold above the point at which the gasoline and air are mixed. Therefore the mixture is thinned out considerably.

Butterfly Valve Loose on Its Shaft. This trouble will cause a fluttering action when the engine is accelerated and the action of the engine will be uneven. It will also cause the throttle to remain open and the engine would race even after the throttle lever or accelerator pedal had been returned to the closed position.

Choke Valve Loose on the Shaft. This would either cause too rich a mixture because it failed to open after the choke lever had

been moved to the open position or the engine would be very hard to start because the choke valve could not be closed to give the rich mixture necessary for starting. Examine the choke wire and the screws that hold the valve on its shaft. Replace them if they are lost or tighten them if they are loose.

Float Failure. Float failure within the carburetor or the vacuum tank is the cause of trouble which frequently defies diagnosis on the part of the mechanic. The logging of the carburetor float or the vacuum tank float will result in a fuel mixture which is overrich. The logged carburetor float will cause the carburetor

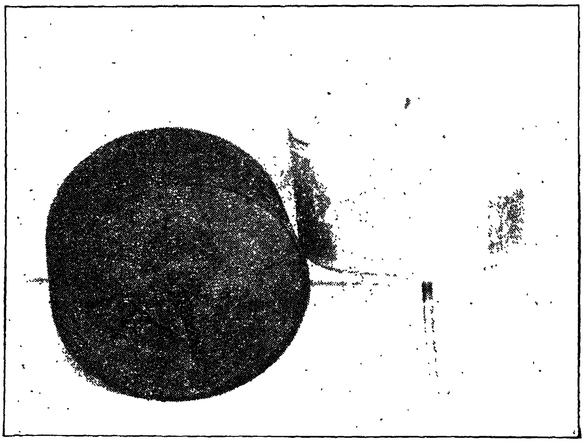


Fig. 166. Vacuum Tank Floats
Left—One which has failed from corrosion.
Right—A new vacuum tank float.

to flood when the car is standing idle. A logged vacuum tank float makes trouble when the car is running.

A vacuum tank float which has corroded and rusted thin with eventual failure is shown at the left in Fig. 166. The float appearing at the right is a new one in good condition. When metal floats fail, it is usually due to some very small opening or leak. Over a long period of time fuel keeps seeping in. When the float is removed from the carburetor and shook near the ear, the sound of the fluid in the float is evident. In order to effect a repair, the best plan is to discard the old float and replace it with a new one. In case the float has to be repaired, the first thing to do is to locate

the opening through which the fuel enters. In order to do this, place a pan of water on the stove and when it has come to the boiling point immerse the float in it. Since the gasoline will vaporize at a point lower than that at which water boils, bubbles will appear emerging from the point at which the leak has occurred. Mark this point.

Enlarge the original leak with a scriber or center punch. At another point, directly opposite this one, punch another hole. The second hole affords a vent for the air to enter while draining the gasoline off. Now proceed to solder both of the holes shut. Then the test given above should be repeated in order to learn whether the job is air tight.

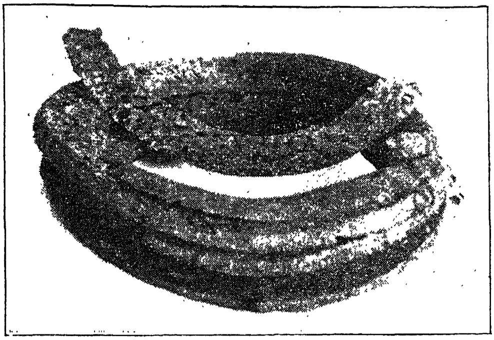


Fig. 167. A Hinged Type Cork Float Which Separated after Losing Its Shellac Coating

Cork floats are constructed of a number of layers of cork which are glued together. The entire outer surface of a cork float is protected by means of a high grade of shellac. When this shellac fails, for any reason, the layers of the cork may become separated, as in the case of the float shown in Fig. 167. The only remedy, of course, is to replace this type of float with a new one, once the damage has become so great. It sometimes happens that the shellac will start to disintegrate and show evidences of failure before the damage is beyond repair. When a float in this condition is met with in service, it is a good plan to re-shellac it to prevent future trouble.

Generally it is not a good plan to try to dry out a fuel logged cork float. Some mechanics, however, have made repairs to the

fuel logged cork float by first drying it in an oven or over a hot plate, and then shellacing it. This procedure is not recommended except in case of the greatest emergency.

Cleaning the Carburetor. Cleaning the carburetor should be done very carefully until one becomes quite familiar with it and with the influence which movement of the various parts will have. First, the gasoline supply should be shut off between the tank and the carburetor so that the supply of gasoline may be saved; second, disconnect the priming arrangement; third, remove the top part of the float chamber. In taking off the top, the cover should be loosened and then lifted straight up until clear of all remaining parts. With the cover off, the float may readily be removed in the same way, the only care being in starting it. As the amount or length of the needle point within the tapered seat is small, the float need be raised but a small amount.

CARBURETORS

(See Vol. II, bottom folios 11 to 202)

BUICK CARBURETORS

The following material has been supplied by the Buick Motor Car Company.

MARVEL CARBURETOR

General Description. The Model "CD-1B" "Marvel" carburetor used on Series 40 and the Model "CD-2B" "Marvel" carburetor used on Series 60–80–90 are of the plain tube, fixed jet type, and have the following features:

1. A mixture adjustment for idle on each barrel of the carburetor.
2. A vacuum controlled step-up, or "Economizer," which insures, automatically, maximum economy for normal operating conditions and full power mixture for acceleration, hill climbing, and high-speed operation.
3. Direct action accelerating pump with pump stroke adjustable for seasonal requirements.

Construction. The carburetor is made up of two major units—a cast-iron double throttle body, fuel bowl and double mixing chamber combined, and a die cast zinc bowl cover and air inlet assembly combined.

The fuel bowl is provided with an atmospheric air vent in the cover and two special additional vents to improve hot engine operation.

Special features are embodied in the nozzle and fuel passage construction to prevent "percolation" of fuel from carburetor nozzles after a hard run in hot weather.

Operation. The carburetor is provided with two floats, two complete idle systems, two main nozzle systems, two metering pin and jet systems, two accelerating pump discharge jets, two mixing chambers and two throttle valves. In the schematic view, Fig. 1, only one of each duplicated system is shown, and the description to follow will deal with these duplicate units as a single system.

Idle System. With the throttle valve slightly open to permit idling, the vacuum below the throttle on the manifold side is high. Very little air passes through the venturi at this time, and with very low suction on the main nozzle it does not discharge fuel. This high suction beyond the throttle, causes the idle system to function, as the primary idle delivery delivers into the high suction zone beyond the throttle.

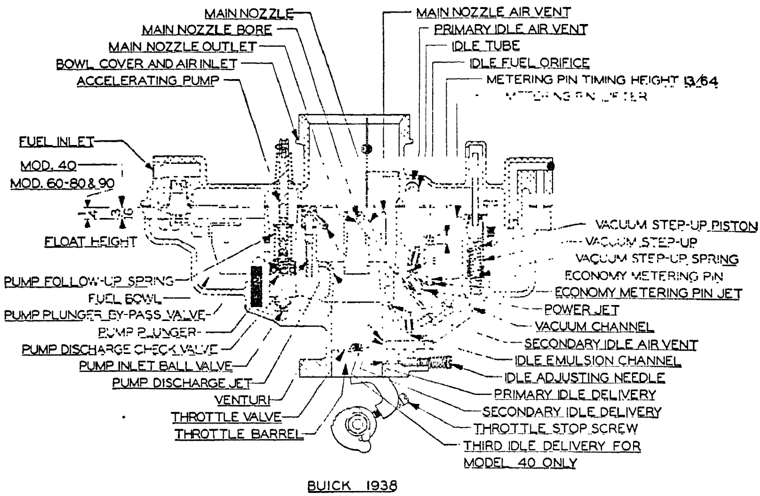


Fig. 1. Buick 1938 Marvel Carburetor
Courtesy of Buick Motor Car Co.

Fuel from the fuel bowl passes through the metering pin and jet, power jet, and into main nozzle bore where it passes through idle fuel orifice in the side of nozzle bore into idle fuel channel, thence through the idle tube where it is mixed with air which is allowed to enter the idle tube through the primary air vent.

The resultant emulsion of fuel and air passes downward through the idle tube to the idle emulsion channel, where an additional amount of air is blended with the emulsion through the secondary idle air vent. This rich emulsion is finally drawn into the throttle barrel through the primary idle delivery opening, subject to the regulation of the idle adjusting needle, where a small amount of air passing the throttle valve mixes with it, forming a combustible mixture for idling the engine.

The idle adjusting needle controls the quantity of rich emulsion supplied to the throttle barrel and, therefore, controls the quality of the "curb idle" mixture. Turning the needle away from its seat enriches the idle mixture to the engine, and turning the needle toward its seat thins the idle mixture.

On "curb idle" some air is drawn from the throttle barrel above the throttle valve through the secondary idle delivery opening and blends with the idling mixture being delivered to the engine, subject to regulation of the idle adjusting needle.

The secondary idle delivery begins to deliver idling mixture to the engine as the throttle is opened, coming into play progressively and blending with the primary idle delivery to prevent the mixture from becoming too lean as the throttle is opened and before the main nozzle starts to feed.

On the Series 40 carburetor a third idle delivery is used to allow smoother progression in the fuel delivery from the idle system to the main nozzle, and is not required in the Series 60 carburetor, because the larger engine pulls more air through the carburetor at the lower speeds causing the main nozzle to deliver sooner.

Metering. All fuel delivery on idle and also at steady car speeds, up to approximately 18 miles per hour, is from the idle system. At approximately 18 miles per hour, the suction from the increasing amount of air now passing through the venturi causes the main nozzle to start delivering, and the idle system delivery diminishes due to lowered suction on the idle delivery openings as the throttle valve is opened for increasing car speeds. The idle delivery is practically nil, until at approximately 40 miles per hour and most of the fuel delivery from that point on to the highest speed is from the main nozzle. However, the fuel feed at any full throttle speed is entirely from the nozzle.

The idle system and the main nozzle are connected with each other by the idle fuel channel. The amount of fuel delivered from either the idle system or main nozzle is dependent on whether the suction is greater on the idle system or main nozzle, the suction being governed by throttle valve position and engine load.

The main nozzle feeds at any speed if the throttle is open sufficient to place the engine under load, which drops the manifold suction. Under such conditions of low manifold suction at the throttle

valve, the main nozzle feeds in preference to the idle system because suction is multiplied on main nozzle by restriction of the venturi.

Main Nozzle. The main nozzle is supplied with fuel which passes from the fuel bowl through the economy metering pin jet. The fuel then passes upward through the nozzle bore where it is mixed with air drawn from the nozzle air vent and is then discharged from the nozzle outlet as an air and fuel emulsion into the mixing chamber. Air passing through the nozzle air vent sweeps fuel from the nozzle bore under very low suction and, therefore, satisfies any sudden demand for nozzle fuel delivery. It also causes the nozzle to feed sufficient fuel at very low speeds with the engine under load.

Vacuum Step-Up (Suction Control Metering Pin "Economizer"). The vacuum step-up works instantaneously with any change in manifold vacuum caused by sudden change in engine load, and is not dependent entirely upon throttle position. It is possible to impose a heavy load upon the engine, particularly at low speeds, in accelerating or climbing a grade, with the throttle only slightly opened, and under these conditions the vacuum step-up operates, giving a full power mixture which eliminates missing, "lean feeling" and "spots," which might otherwise occur if the engine were operated under heavy load with a lean mixture.

In part throttle acceleration on a level road, the mixture is "stepped up" to a power mixture only temporarily, because as the engine speed increases with the throttle in one position the manifold vacuum increases, and immediately pulls the metering pin back into the jet. Likewise, during the warm-up period after starting cold, the vacuum step-up operates automatically and instantaneously when the engine falters and thus reduces the amount of choking necessary to smooth operation.

Fig. 1 shows the vacuum step-up and the vacuum channel transmitting the vacuum below the throttle to the vacuum step-up piston. The vacuum step-up piston, to which is attached the metering pin lifter, is drawn downward by high suction below the throttle valve, against the pressure of the vacuum step-up spring and thus lowers the metering pin into the economy metering pin jet thus providing a lean mixture for part throttle economy. When the suction below the throttle is low, the metering pin is raised from the economy metering pin jet.

The power jet then meters a richer full power mixture for full throttle or heavy load. The vacuum step-up spring is calibrated to allow the metering pin to remain in the jets for maximum economy up to a car speed of approximately 75 miles per hour on a level road.

Accelerating Pump. The accelerating pump discharges fuel only when the throttle is moved toward the open position, and provides additional fuel to keep in step with the sudden inrush of air into the manifold when the throttle is opened.

Through a walking beam and a system of levers, the accelerating pump plunger is moved downward when the throttle is opened, thus forcing fuel past the pump discharge check valve, through the pump discharge jet into the mixing chamber. On closing the throttle, the accelerating pump plunger moves upward, thus refilling the pump chamber by drawing fuel from the fuel bowl through the pump inlet screen and pump inlet ball valve.

On any quick opening of the throttle, the pump follow-up spring yields and permits the pump plunger to prolong the pump discharge. Also, built into the pump plunger is a pump plunger by-pass valve, which on rapid movement of the throttle permits a portion of the accelerating charge to by-pass the plunger back to the fuel bowl, thereby aiding the pump follow-up spring in preventing "slugging" of a warm engine with fuel.

The valve spring above the plunger by-pass valve is strong enough to hold the valve on its seat for normal operation of the throttle, preventing loss of accelerating charge to the engine, except when the throttle is opened quickly, as above described.

Adjustment. If, after checking all other points on the engine, it is found necessary to readjust carburetor, proceed as follows: With the engine thoroughly warmed up, set throttle stop screw which bears against cold idle control cam mounted on intake manifold so that the engine idles at a speed equivalent to 7 to 8 miles per hour on a level road.

There is one idle adjusting needle for each barrel of the carburetor. Adjust each barrel separately. Turn the idle adjusting needle out slowly until the engine "rolls" from richness, then turn the needle in slowly until the engine "lags" or runs irregularly from leanness. This step will give an idea of the idle adjustment range and of how the engine operates under these extreme idle mixtures.

From the lean setting turn the needle out slowly to the richest mixture possible that will not cause the engine to "roll" or run unevenly. Repeat this procedure on the other barrel. This adjustment will in most cases give a slower idle speed than a slightly leaner adjustment, with the same throttle stop screw setting, but it will give also the smoothest road operation.

A change in idle mixture will change the idle speed and it may be necessary to readjust the idle speed with the throttle stop screw to the desired point. The idle adjusting needles should be from ¾ to 1 turn from their seats to give a satisfactory idle mixture.

Caution. Do not turn needles tightly against seats, as grooves will be cut into the needles by the seats and will make a satisfactory adjustment difficult to obtain.

LINCOLN CARBURETOR

The Stromberg type Double E carburetor, as used on the Lincoln car, is of the plain tube dual down-draft type, with all orifices being fixed. The mixture used throughout the operating range is determined by the size of the main metering jet, Fig. 2. The mixtures for idling and closed throttle operation are controlled by the idling adjusting screws as shown in Fig. 2. These screws operate on a predetermined mixture of gasoline and air, and turning them clockwise provides a leaner mixture.

As the carburetor supplies mixture to the two cylinder blocks individually, either one of the adjusting screws should be turned in or out, as found necessary, until the fastest and steadiest running position from that throttle is obtained. These screws adjust the mixture that is fed by either the right or left carburetor barrel. The right barrel feeds the right block and the left barrel feeds the left block.

Adjust either idling adjusting screw so that six cylinders fire smoothly. Cutting out one block of cylinders by shorting the low tension distributor wire is a good method to use when making the idle adjustment.

The throttle stop screw should be adjusted to give the minimum idling speed. If the engine idles too fast or too slow, after completing the idling adjustment, the throttle stop screw should be adjusted, by turning the screw clockwise to increase the engine speed, and turning the throttle stop screw anti-clockwise so it will reduce the speed.

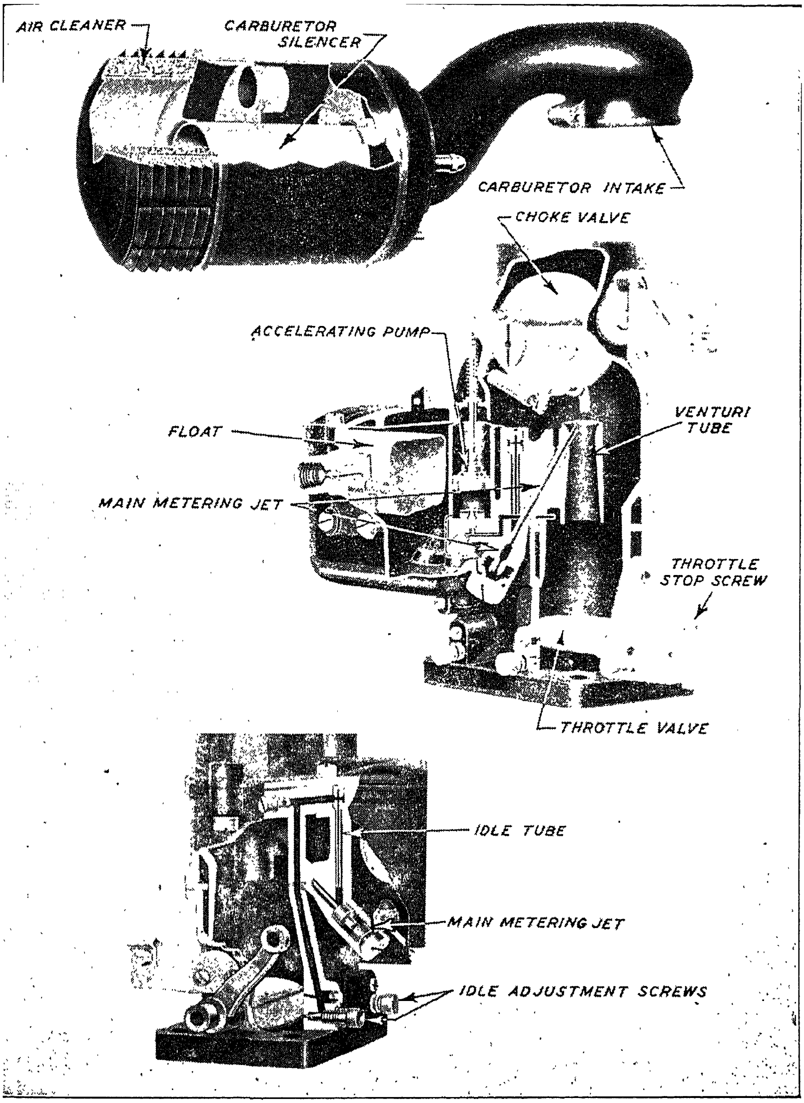


Fig. 2. Lincoln Carburetor
Courtesy of Ford Motor Co.

Before any carburetor adjustments are made, the engine should be run long enough so that the water in the radiator is heated sufficiently to cause the radiator shutters to open fully.

To determine if fuel is being supplied to the carburetor, remove either of the float chamber plugs to check for fuel at that point.

The carburetor adjustment should never be changed until all other possible sources of trouble have been investigated. Spark plug points and distributor breaker points should be properly adjusted and cleaned.

Compressions should be good and equal in all cylinders.

Intake manifolds and carburetor base and connections should be checked for air leaks.

The accelerating pump shown in Fig. 2 can be adjusted for winter and summer operation and should be changed accordingly.

A greater discharge from the accelerating pump is desirable in the winter, and this can be obtained by assembling the accelerating pump rod in the hole farthest from the center of the throttle stem. Assembling the pump rod in the hole nearest the center of the throttle stem will cut down the discharge from the accelerating pump. This makes it also desirable for summer adjustment.

For normal running the carburetor choke control button on the instrument panel should be pushed all the way in, and should be in that position to make continuous use of the engine. It also must be in while making carburetor adjustments.

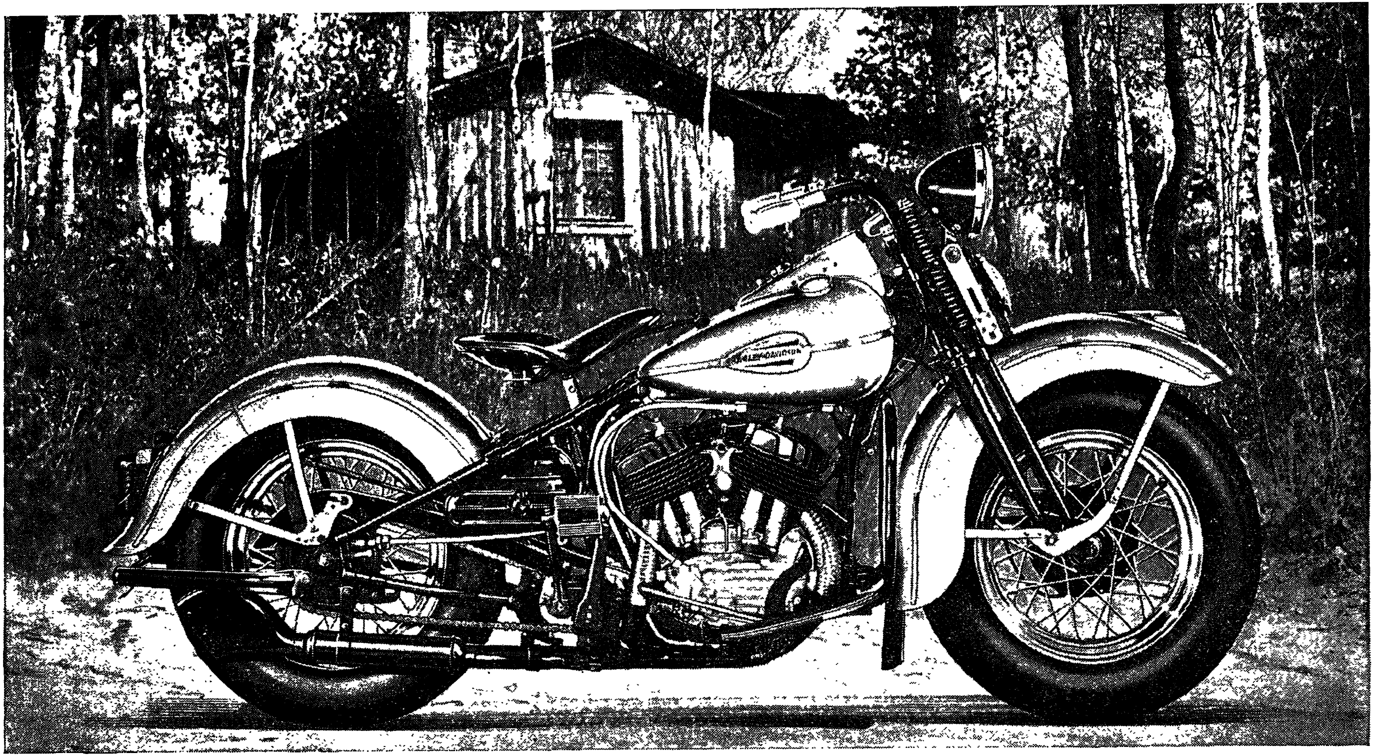
A valve in the air intake of the carburetor is operated by the choke button. When the choke is used the amount of air admitted to the carburetor is decreased, causing a richer mixture to be formed, which is necessary for starting purposes. The choke should be used for starting and warming up the engine only, and then as little as possible.

If the choke is used when starting a warm engine, the mixture may become too rich preventing the charge being ignited readily, in which case the engine should be cranked with the throttle all the way out, and without using the choke.

The carburetor silencer and air cleaner are attached to the carburetor air intake. The air cleaner is located at the forward end of the unit, and it not only cleans the air going into the carburetor, but it also reduces carburetor noise.

To be sure that the engine obtains the correct amount of air at all times, the cleaner should be cleaned out periodically. The length of time between cleaning depends upon the conditions of the roads upon which the car is operated.

The air cleaner can be cleaned by removing it and washing it in gasoline, after which the unit should be thoroughly dried and then submerged in a good grade of engine oil and allowed to drip dry before installing.



1946 HARLEY-DAVIDSON MOTORCYCLE WITH 45-CUBIC INCH SIDEVALVE
Courtesy of Harley-Davidson Motor Company

CARBURETORS

FORD, MERCURY, AND LINCOLN-ZEPHYR CARBURETORS

The carburetors used on the 1939 Ford models, the Mercury and the Zephyr are of similar design and construction. They are of the

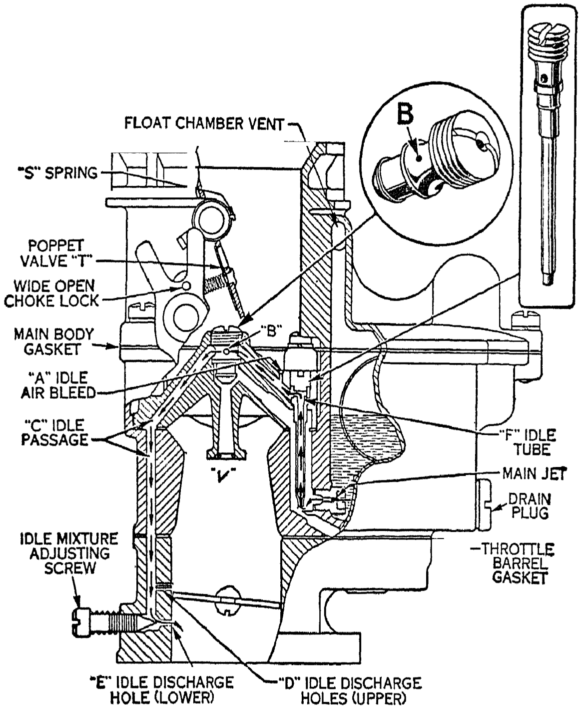


Fig. 1. Ford-Mercury-Zephyr Idle Fuel Supply
Courtesy of Ford Motor Company

plain tube type. The jet and venturi sizes, as well as the float level, vary for the different models. The fuel level for the Ford type is $^{23}/_{32}$ inch maximum and $^{21}/_{32}$ inch minimum. The level for the Lincoln-Zephyr is $^{21}/_{32}$ inch maximum and $^{19}/_{32}$ inch minimum. The general design and construction of the carburetor is illustrated in Figs. 1 to 4, inclusive.

In this carburetor all the main gasoline channels are provided

in a removable nozzle rail or bar which is indicated at the inset X in Fig. 2. As in all carburetors, the float M in the float chamber, Fig. 2, controls the level of the gasoline therein. Air entering the top of the carburetor at Z blows down past the nozzle bar and the main discharge nozzle, which is located at the smallest portion of the venturi marked V in Fig. 1. The amount of air flowing is controlled by means of the throttle plate marked T, Fig. 2. The reader

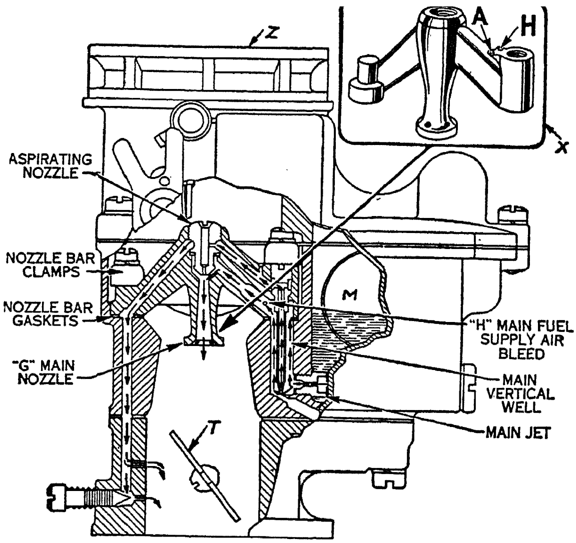


Fig. 2. Ford-Mercury-Zephyr Main Fuel Supply
Courtesy of Ford Motor Company

should make a careful study of the four figures reproduced, in order to learn the location of the various jets and passages. The carburetor used is of the dual type with separate sets of venturi, idle tubes, nozzle bars, main metering system, idle system, and throttle plate for each barrel. There is but one accelerating pump; however, the flow of fuel from the pump is divided by the pump discharge nozzle, shown in the inset Y, Fig. 4. There is but one fuel chamber and one float or gasoline chamber. There is one power valve which takes the fuel from the fuel chamber through one passage and divides the fuel evenly for each side of the carburetor. Operation for the barrels is identical.

Choke. In the case of an initial start with the engine cold, the choke button is pulled out on the dash, which results in the throttle valve being automatically opened to the correct position for starting. It is not necessary for the driver to pull out the throttle button, or to pump the accelerator when starting. With full choke, the valve is held in a locked position by the control lever. If the choke is held in this position after the engine starts firing, a small poppet valve or air bleeder *T*, Fig. 1, opens to allow air to pass. This is so designed as to produce a certain amount of noise to attract the driver's attention to the fact that the choke is in closed position, and the choke button should be returned to normal operating position. The torsion spring *S* tends to close the choke valve when part-choke position is selected by the driver. As the engine speeds up, the inrushing air tends to force the valve open and thus compensate for the increased speed. While this helps to provide smooth operation in part-choke position, the choke button should be returned to normal position just as quickly as possible.

Idle Fuel Supply. Following the arrows in Fig. 1, it will be noted that the fuel flows from the carburetor bowl through the main metering jet and into the idle tube *F*. An idle air bleed *A*, Fig. 1 and inset, introduces air into the fuel. An additional small amount of air is bled in by the hole *B* in the aspirating nozzle, inset, Fig. 1. The idle mixture of gasoline and air goes around the aspirating nozzle *B* and travels down the idle passages *C* to the idle discharge holes *D* and *E*, as shown in Figs. 1 and 2. With the engine set to rotate at a speed of 350 revolutions per minute, the mixture will be discharged out of the lower hole *E* only, and as the throttle plate opens and the speed is increased, the upper hole *D* will start discharging at about 450 revolutions per minute. These upper holes will start discharging very gradually from about 450 revolutions per minute, reach their maximum about 750 revolutions per minute, and taper off to about 1250 revolutions per minute of the engine. They thus become less effective as the main nozzle starts to discharge.

The lower discharge hole *E* is provided with an idle mixture adjustment in the form of a screw. Turning this screw needle out gives a richer mixture, and in gives a leaner mixture.

Adjusting the Idle Jets. Since a dirty air silencer or air cleaner may present a considerable restriction to the air coming into the

carburetor, it will result in too rich a mixture, and for this reason it is necessary to remove and clean the air silencer before proceeding with the adjustment. Next, connect the vacuum gauge to the intake manifold windshield wiper connection. The vacuum gauge is a device which is used to give the relative vacuum reading developed within the intake manifold when the engine is operating. Next, check for any vacuum leaks as they will upset the fuel air ratio. The points most likely to provide such leaks are at the windshield wiper and the distributor vacuum control connection, or at the connections of any vacuum-operated accessories with which the car is equipped. It is a good plan also to tighten the intake manifold nuts to assure the manifold seating itself in the gasket properly. If there are any leaks which you are curing, the result will be an increase in the vacuum gauge reading.

Now proceed to set the engine revolutions per minute at 350. Adjust one jet at a time by first turning the jet in or out until the highest reading is obtained. Then turn the second jet, which is the idle adjusting screw, in or out until the highest reading is obtained. If too rich a mixture is secured, it will cause a weaving of the vacuum hand, while too lean a mixture will cause a sudden drop and reduces the reading of the hand.

Main Fuel Supply. As the speed of the engine reaches approximately 900 revolutions per minute, the main nozzle *G*, Fig. 2, starts to deliver fuel which is mixed with the fuel being supplied by the idle system. Between 900 revolutions per minute and 1250 revolutions per minute, there is a blending of the mixtures coming from the idle system and the main metering system. The power valve *J*, Fig. 3, remains closed during this range, and up to approximately 3800 r.p.m., except when under heavy load, which would cause the manifold vacuum to drop. The path of the fuel during this range is through the main jet, as shown in Fig. 2, up through the main vertical well, then up and around the idle tube. The main supply of fuel is emulsified by air entering at the main fuel supply air bleed *H*, which lightens the fuel and makes the mixture more responsive to sensitive throttle changes. A further aspiration is supplied by the aspirating nozzle as the fuel starts down the main nozzle *G*. A nozzle bar, inset *X*, Fig. 2, one for each carburetor barrel is held in place by clamps and the channels sealed against

leaks by the nozzle bar gaskets. It is well to exercise care in disassembling and reassembling these nozzle bars, seeing that the gaskets are in place and in good condition to seal when the clamp screws are tightened. In order to prevent any damage to the metering orifice in the jet, be sure to use a screw driver, the end of which has been machined or ground to fit the slot in which it is used.

As the throttle of the engine is opened, there is a lessening of the vacuum in the carburetor and manifold. When the throttle plate

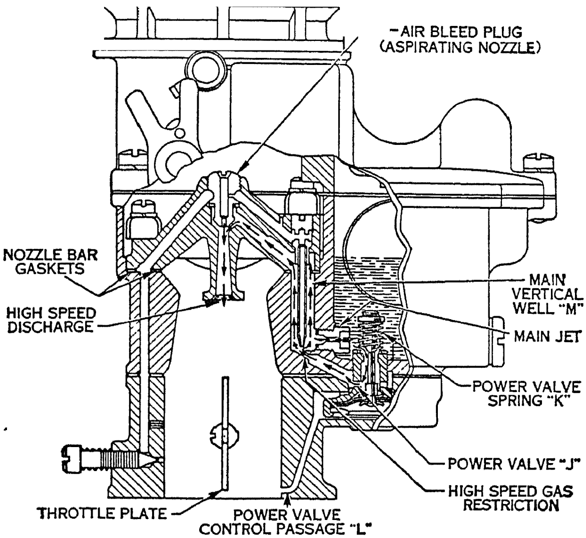


Fig. 3. Power Fuel Supply
Courtesy of Ford Motor Company

has been opened to a point which will allow the car to operate on the road with an engine speed of approximately 3800 r.p.m., the power valve will open, due to the spring pressure overcoming the vacuum within the carburetor. This occurs at approximately 8½ to 9 inches of mercury. The same action occurs when climbing hills or in any other operation where the greatest amount of power is required and when the throttle plate is opened wide. When the spring actuated valve has opened, whether on level road or on hills, fuel will flow into the power valve and through the fuel passages or channels and through the high speed gas restrictions into the center or main vertical well *M*, as shown by the arrows in Fig. 3. Thus the additional fuel

required for high speeds and heavy loads at full throttle low speed is secured.

The Accelerating Pump. When the throttle is closed, fuel is drawn into the pump chamber through the pump inlet check valve, *N*, Fig. 4. Since the throttle is connected to the accelerating pump piston *O*, the opening of the throttle causes the piston to move down,

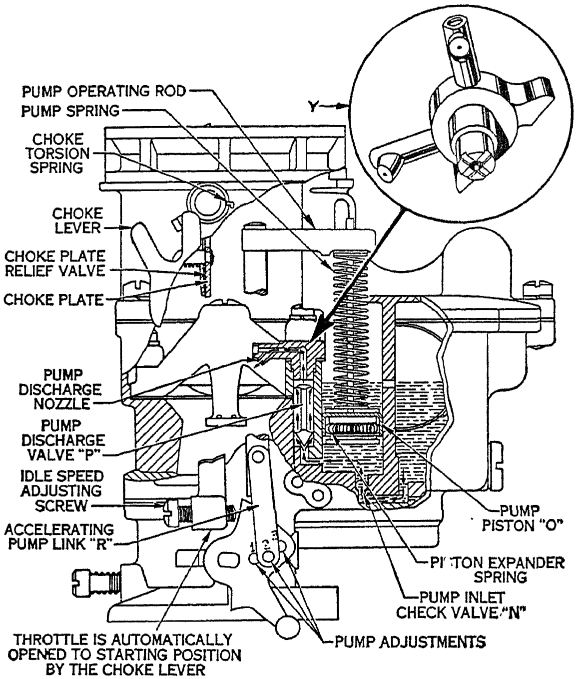


Fig. 4. Ford-Mercury-Lincoln-Zephyr Accelerating Fuel Supply
Courtesy of Ford Motor Company

closing the pump inlet check valve and overcoming the weight of the pump discharge valve needle. When this happens, the accelerating fuel forced out then passes around the pump discharge valve *P* and out the pump discharge nozzle, illustrated in the inset *Y*, Fig. 4. In order to provide for a long discharge of the accelerating fuel, when accelerating rapidly, spring loading is provided in the piston stem and the pump operating rod. A pump link rod *R*, Fig. 4, is provided to allow for the three positions marked 1, 2, and 3. Of

these, the No. 2 is the average setting, No. 1 is the setting for summer or hot weather, and No. 3 for extremely cold weather. If the accelerating pump should fail, the most likely point to search for the trouble is dirt under the pump inlet check valve *P*. In order to check for this, remove the carburetor air horn and operate the pump with just a small amount of fuel in the carburetor bowl. If the check is leaking, air or fuel will bubble back into the fuel bowl from the inlet hole. When reinstalling the pump piston, make very certain that the leather is not damaged.

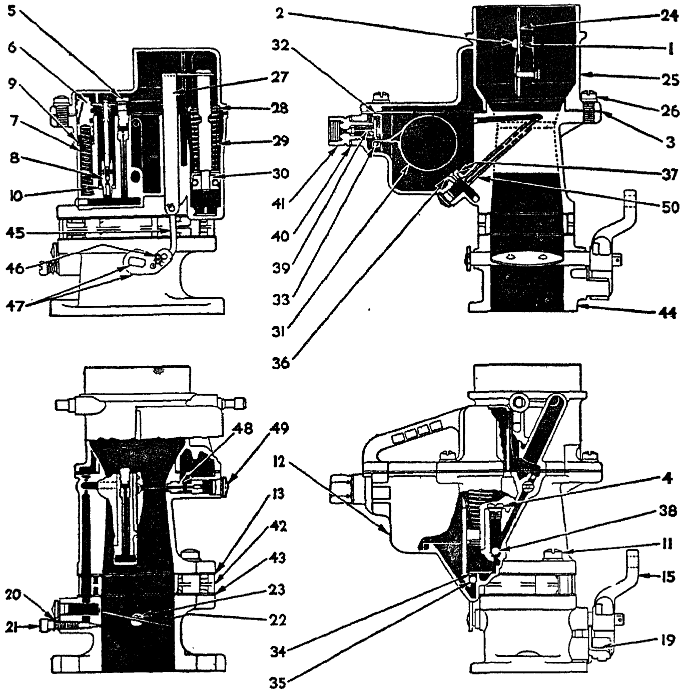
PLYMOUTH 1939 CARBURETOR ADJUSTMENT

The carburetor is of the plain tube, down-draft type with fixed jets which cover all speed ranges except the idle range, which is controlled by an adjusting needle. The carburetor is equipped with an adjustable accelerating pump and fast idle device for the prevention of stalling with a cold engine. The idle needle valve controls the fuel mixture for idling. Turning the adjusting screw *21*, Fig. 5, clockwise gives a leaner mixture and counterclockwise a richer mixture. When adjusting a carburetor, it is a good plan to use a vacuum gauge and adjust the idle needle valve to obtain the highest reading.

In order to provide the additional fuel required for rapid acceleration, the carburetor is equipped with a pump which supplies an extra charge of fuel momentarily as the throttle is opened. This pump is shown as *30*, Fig. 5.

Three positions are provided on the accelerator pump lever *47*, Fig. 5, in order to give a greater or lesser discharge of fuel, depending upon climatic conditions. For extremely warm weather or for high altitudes above 3,000 feet, the pump link should be in the hole in the accelerating pump lever which is nearest to the throttle shaft. This gives the shortest stroke of the pump. For cold weather operation, the pump link should be in the pump lever hole which is farthest from the shaft. For normal summer temperatures the pump link should be in the center hole.

For high altitudes (3,000 feet and higher) leaner main metering screws *36*, Fig. 5, are available through the Plymouth service parts departments. A main metering screw is installed by removing the carburetor float cover and float. Then, remove the metering screw.



1. Valve attaching screws.
2. Choke control lever and shaft.
3. Body gasket.
4. Pump check plug.
5. Idle orifice tube and plug.
6. Step-up piston, plate and rod.
7. Step-up piston spring.
8. Step-up jet.
9. Step-up piston gasket.
10. Step-up jet gasket.
11. Flange attaching screw.
12. Body.
13. Flange gasket.
14. Choker connector rod.
15. Throttle shaft lever.
16. Throttle lever clamp screw.
17. Throttle lever adjusting screw spring.
18. Throttle lever adjusting screw.
19. Throttle shaft dog.
20. Idle adjustment screw spring.
21. Idle adjustment screw.
22. Throttle valve.
23. Valve attaching screw.
24. Choke valve.
25. Air horn.
26. Air horn attaching screw.
27. Pump operating link.
28. Pump spring retainer.
29. Pump spring.
30. Plunger, spring and rod.
31. Float and lever.
32. Float lever pin retainer.
33. Float lever pin.
34. Pump retainer ring.
35. Pump cylinder ball.
36. Main metering jet.
37. Main metering jet gasket.
38. Pump check ball.
39. Float needle.
40. Float needle seat gasket.
41. Float needle seat.
42. Insulator.
43. Flange gasket.
44. Body flange.
45. Pump connector link.
46. Pin lock spring.
47. Throttle valve shaft and arm.
48. Pump jet.
49. Pump jet rivet.
50. Main vent tube.

Fig. 5. 1939 Plymouth Carburetor
Courtesy of Chrysler Motors, Plymouth Division

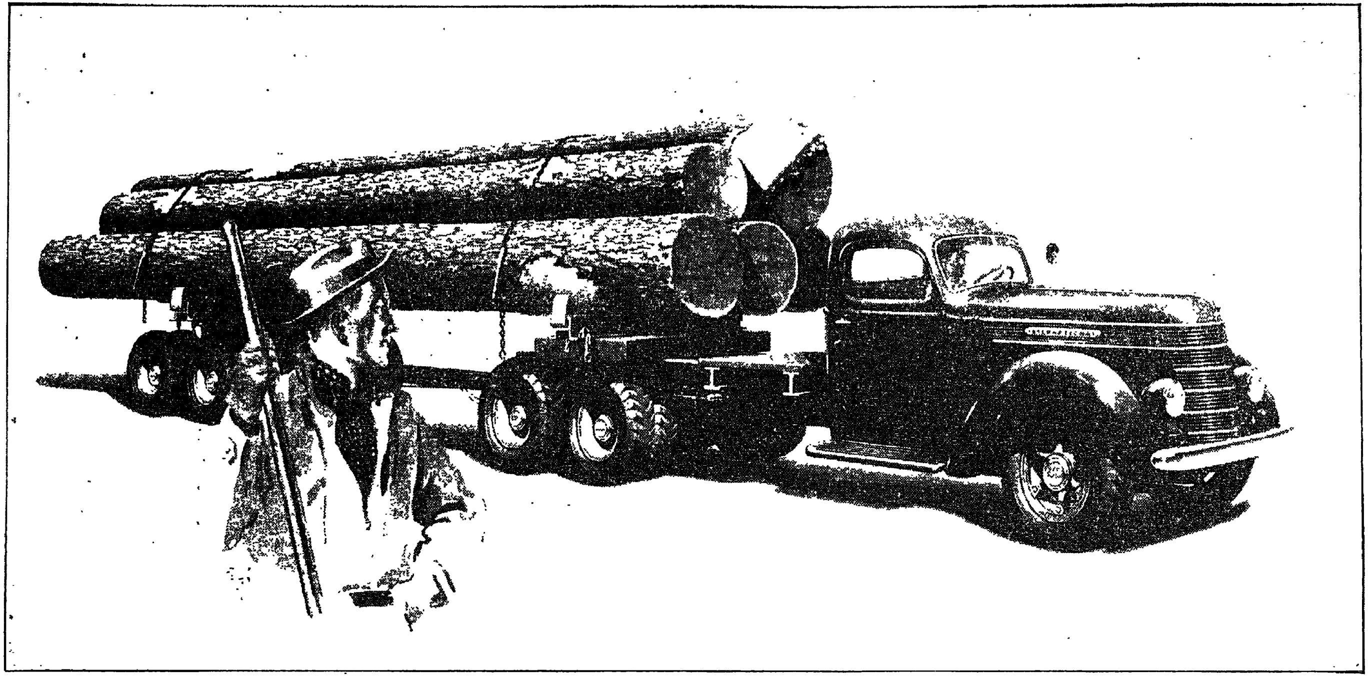
Install the replacement metering screw and assemble. If leaner metering screws are used in lower altitudes, the maximum speed and power developed by the engine will be materially reduced, but slightly greater fuel economy may be obtained. However, it is

recommended that the standard metering screw as furnished with the carburetor at the factory be used to obtain best general performance.

To check float level, first remove float chamber cover and gasket. Then measure the distance from the top of float chamber to top of float. This should be $\frac{5}{64}$ inch and can be reset, if necessary, by bending the lip on the float lever *31*, Fig. 5, away from needle to raise float, and toward needle to lower float level. Bend vertical lip of float only.

When tests are being made for speed or fuel economy, they should be made on hard surfaced roads if possible. Speed or economy tests should not be made against the wind, and if it is impossible to run the test with a side wind, several runs should be made with and against the wind, and the average taken for these runs.

An automatic choking devise is provided as special equipment, and operates the carburetor choke when starting and during the warm-up period of a cold engine. After the engine reaches normal operating temperature, the choke opens and remains open until the manifold has cooled. When checking operation of automatic choke, be sure the engine is cold; otherwise, the choke will be open. Open hand throttle one fourth way and remove air cleaner. Move automatic choke lever until hole in brass shaft lines up with slot in bearing. Insert adjusting tool through shaft, pushing the tool all the way down. Loosen the clamp screw on the automatic choke lever and push the lever upward until the carburetor choke valve is closed tight. Holding the lever in this position, tighten the clamp screw in the lever, remove the adjusting tool and replace the air cleaner, making sure that tightening the clamp does not bind the choke valve or shaft and that the fast idle or choke mechanism does not bind, causing interference with the carburetor choke valve. Always check this adjustment with the throttle partly open.



INTERNATIONAL SIX-CYLINDER TRUCK-TRACTOR WITH DUAL REAR AXLE, DRAWING TRAILER WITH DUAL REAR AXLE. 18 TIRES

Courtesy International Harvester Company, Truck Division

CARBURETORS

1941 BUICK COMPOUND CARBURETION

The standard carburetor equipment on the 1941 Buick cars may be either the Stromberg or the Carter carburetors. The Series 40 engines are equipped with one dual carburetor, while other series are equipped with two dual carburetors, making for compound carburetion. Fig. 1 shows the Buick engine fitted with compound carburetion. Manifolding on all of these engines is of the dual type. This is illustrated in Fig. 2. The outside branch of the manifold is connected to the outside barrels of both carburetors and feeds cylinders Nos. 1, 2, 7, and 8, or the end cylinders, while the inside branch of the manifold is connected to the inside barrel of both carburetors and feeds the center cylinders; that is, Nos. 3, 4, 5, and 6. With this arrangement either carburetor can feed to all eight cylinders.

The front carburetor is a complete carburetor, including the float system, main-metering system, accelerating pump, power by-pass system, idling system, starter switch, and automatic choke, while the rear carburetor contains only a float system, idling system, and main-metering system.

In operation, when the engine is idling up to approximately 22 miles per hour on part throttle, the idling systems of both carburetors are in operation. A damper valve assembly is used between the rear carburetor and intake manifold. This is illustrated in Fig. 3. This valve is ordinarily held in closed position by an offset weight and serves to govern the operation of the rear carburetor. The butterflies in this valve assembly are not a tight fit, and thus they allow the idling system of the rear carburetor to operate with the valve in closed position.

The throttle, rods, and levers are so arranged that the throttle of only the front carburetor is opened until a position is reached which will give approximately 75 miles per hour on part throttle. Up to this point of opening the front carburetor only operates, excepting for idle of the rear carburetor, as previously described. Any additional

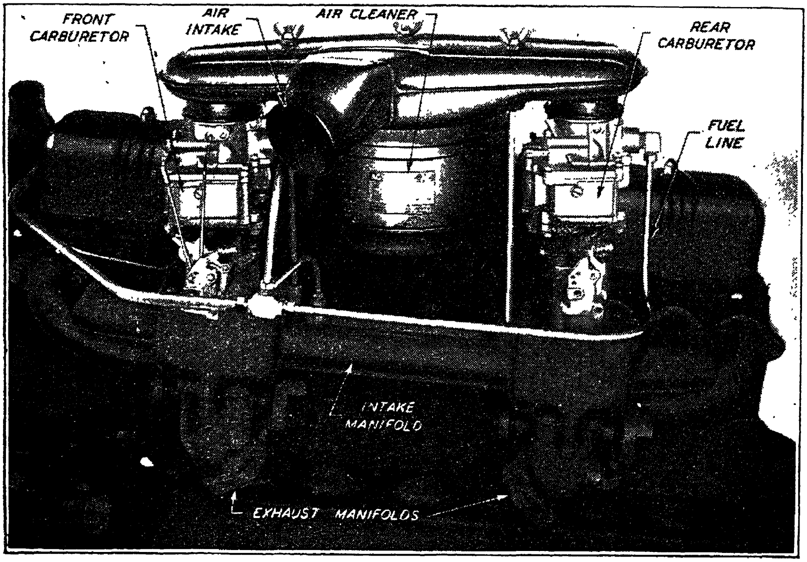


Fig. 1. Buick 1941 Engine Equipped with Compound Carburetors

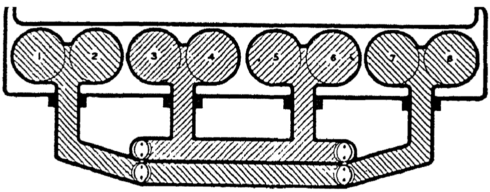


Fig. 2. Intake Manifold Distribution of Buick Compound Carburetion System

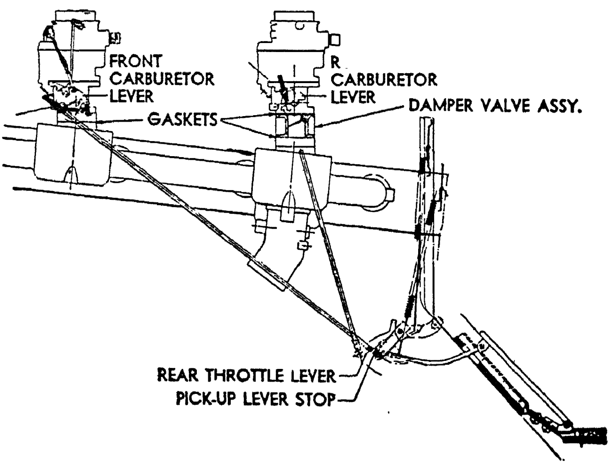


Fig. 3. 1941 Buick Throttle Linkage Adjustment for Compound Carburetion
Courtesy of Buick Motor Division, G. M. S. C.

movement of the accelerator pedal will start to open the throttle of the rear carburetor. The opening of the rear carburetor throttle allows the air to flow through the rear carburetor to open the damper valve and bring the rear carburetor into operation. Thus when the throttles of both carburetors are fully opened, the front and the rear carburetors both feed equally. In case the accelerator pedal is fully depressed at low speeds, only the front carburetor operates until the manifold vacuum is sufficient to open the butterflies of the damper valve assembly on the rear carburetor. This will begin to occur at approximately 15 miles per hour.

OILING AND AIR CLEANING SYSTEMS

A-C HEAVY DUTY OIL BATH AIR CLEANER AND SILENCER

Fig. 1 illustrates the A-C heavy duty air cleaner as used on the Pontiac 1941 automobile. This same type equipment is used on certain other products of General Motors. The unit which is illustrated in

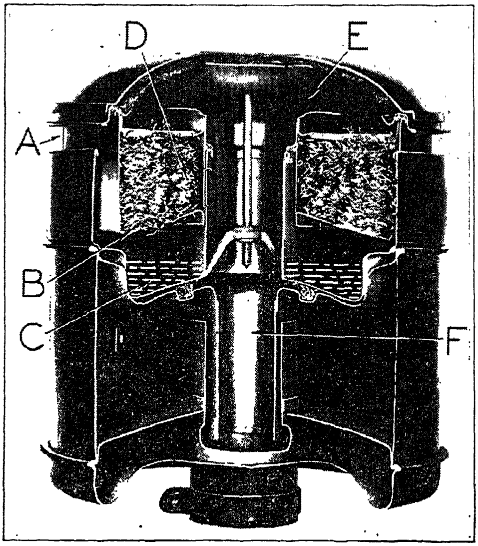


Fig. 1. A-C Heavy Duty Oil Bath Air Cleaner as Used on the 1941 Pontiac
Courtesy of Pontiac Motors Division, G. M. S. C.

part sectioned view is both an air cleaner and silencer. It is of the heavy duty self-washing type, designed especially for the Pontiac car. In operation, the device makes a thorough job of removing dust particles from any air passing through it. The dusty air enters the cleaner through the louvers around the top, as indicated by the arrow *A*, at which time the air reverses direction and passes downward to the annular venturi marked *B*. The increased velocity of the air stream causes the heavier dust particles to impinge upon the oil

supply, indicated by arrow *C*. The high velocity of the air stream picks up some of this oil and carries it upward into the oil-wetted filter element, which is shown at *D*. At this point the oil separates from the air stream and is recirculated for further use. This constant circulation of oil between the base and the filter element serves to keep the element washed at all times, and returns the impurities which collect to the base of the cleaner, where they settle out of the

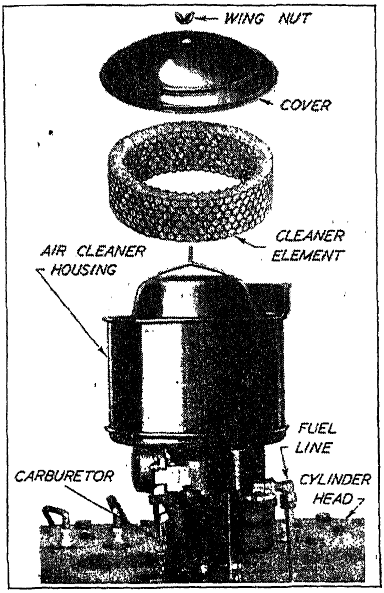


Fig. 2. Pontiac Standard Equipment Air Cleaner
Courtesy of Pontiac Motors Division, G. M. S. C.

oil in the form of mud. The clean air passes through the chamber *E* and downward through the tube *F* into the carburetor.

In order for the air cleaner to function properly, it should have a certain amount of attention. It is necessary after each 5,000 miles to remove the wing bolt from the top of the air cleaner, lift out the cover and pad assembly, remove the filter element, and wash the accumulated dirt from the filter element by plunging it up and down in a pail of gasoline or kerosene. It is also necessary to clean out the accumulated dirt or mud from the oil reservoir and fill to the indicated level with an S. A. E. 50 grade of oil. In extreme cold weather, the oil

should be S. A. E. 30. It is not necessary to oil the filter, as this is automatically done by the operation of the cleaner.

PONTIAC AIR CLEANER AND SILENCER

The design of the regular equipment Pontiac air cleaner and silencer is shown in Fig. 2 in part disassembled view. The cleaner should be inspected each 1,000 miles of operation and cleaned if necessary. In any case, it should be cleaned at least once each season, or every 5,000 miles. In order to do this, first loosen the thumb nut and remove the end plate of the cleaner, which serves to hold the silencing pad which is shown immediately above the cleaner body and below the pad. Dirt may be washed from the cleaner element by plunging it up and down in a can of gasoline or kerosene. After it has had a chance to dry, it should be re-oiled by dipping the cleaner element in heavy cylinder oil, preferably S. A. E. 50, after which allow the excess oil to drain off before reassembling the cleaner. The cleaner works on the principle of passing air, with any accumulation of grit or dust which it may have picked up, through the cleaner element, where the heavy particles of grit or dust are caught and held by the oil film in the cleaner element. The felt pad should always be removed before washing and re-oiling the cleaner.

COOLING SYSTEMS

Heat and energy are closely interrelated. In order to develop power or energy within the gasoline engine, it is necessary to have the fuel burned. The burning or combustion of the gasoline and air mixture results in very high temperatures being developed. Part of the energy developed by this combustion is used up in the power generated. A very large percentage of it must be dissipated through some cooling means. Engineers are always hoping for the time when a larger percentage of the power developed with the burning of the fuel can be utilized. In order to make use of the principles of the internal combustion engine, considerable thought has had to be exercised with reference as to what should be done with the unused heat energy and how it might most efficiently be dissipated without harmful effects to the mechanical parts of the power plant.

Parts Cooled. The parts of an engine requiring cooling are illustrated in Figs. 1 and 2. In Fig. 1, which is a cross section of a water-cooled job, it will be noted that the spark plug, valve, piston, and piston rings are shown along with the cylinder, the cylinder head, valve port, valve guide, and attendant parts. These are the main parts which require efficient cooling.

When the explosion occurs within the cylinder head, a very high initial temperature is developed. The burning gases will show a temperature running well over 2000° F. These burning gases are playing upon the piston head and within the combustion chamber. When the exhaust valve opens, they are playing around the valve stem and seat and through the exhaust port. The spark plug points are in close contact with them; in fact, every surface within the exhaust manifold or within the combustion chamber is subject to them. These gases are actually hotter than the melting point of certain of the metals used in the construction of the engine. If they were continuous rather than intermittent, the difficulty of cooling the engine would be much greater.

One of the situations taken advantage of with reference to cooling engines is the admission of relatively cool gases to the combustion chamber in each cycle of the engine. This holds with reference to

two-cycle and four-cycle engines alike. The cool gases, of course, are likewise in immediate contact with the various parts so that they

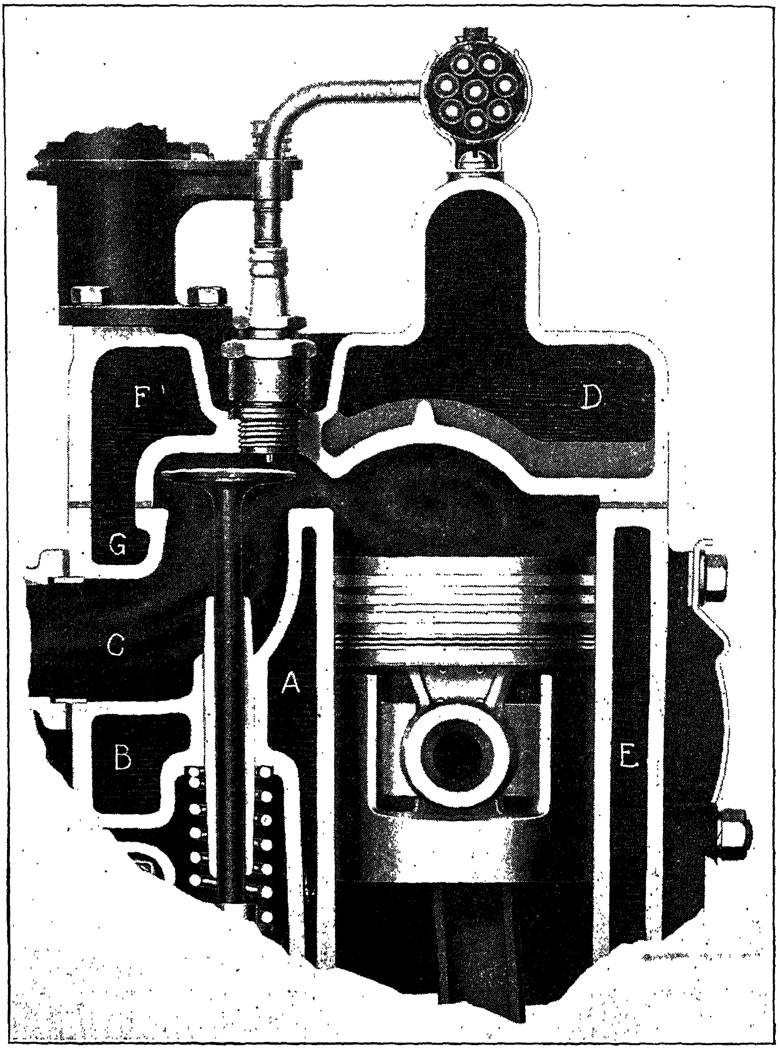


Fig. 1. Parts Which Must Be Cooled

serve to reduce the operating temperature of the parts by immediately absorbing a certain amount of the heat which has been left within the metallic parts by the high temperature of the exploding

gases. The effect of the cooled incoming fuel charges is not sufficient to hold the engine parts at a low enough operating temperature to prevent failure of the engine due to overheating.

Types of Cooling Systems. In the case of an engine of the general characteristics of that shown in Fig. 1, we have what is termed a water-cooled engine. Water is used as an element or medium for transferring the heat from the metallic parts of the engine to the radiator, from which point the heat is dissipated into the air by means of the cooling fins of the radiator and the currents of air which are forced through it by driving or by the action of the fan.

By referring to Fig. 1, it will be noted that definite provision has been made for using water in jackets surrounding the parts which require cooling. The cylinder is surrounded by the water jackets *A* and *E*. Heat within the cylinder is carried through the cylinder wall into the cooling water. Heat which strikes the piston head is first transmitted to the piston body from which point it flows to and through the oil film surrounding the piston and thence into the cylinder wall and to the water. Spark plugs are set into the cylinder head in most cases. The water spaces in the cylinder head are shown at *F* and *D*. It will be noted that the spark plug is effectively cooled by this body of water. This same body of water also conducts away much of the heat which is developed within the combustion space since, unlike the cylinder walls, it is always in contact with the gases in the combustion chamber.

Valves are subject to burning if they are not properly cooled. Cooling the valve seat requires very careful designing. Heat which is taken up by the valve is held within it until such time as the valve is in contact with the valve seat. This metal contact between the valve head and valve seat is the only direct means of valve cooling. It is very likely true that the valve operates at a higher temperature than any other part of the engine. It can also be seen that if the valve seat is not in good condition, the heat is not readily dissipated from the valve into the cylinder block metal. In the case shown in Fig. 1 when the valve is seated, the heat then flows into the metal surrounding the water jackets *A* and *G* and is picked up by the water to be dissipated by the radiator.

In order to keep the valve guide at a satisfactory working temperature, some manufacturers, as in the case of the engine, Fig. 1,

make use of a water jacket surrounding this guide. This dissipates or carries away much of the heat which finds its way into the valve stem.

Oldsmobile Cooling System. The Oldsmobile system of water

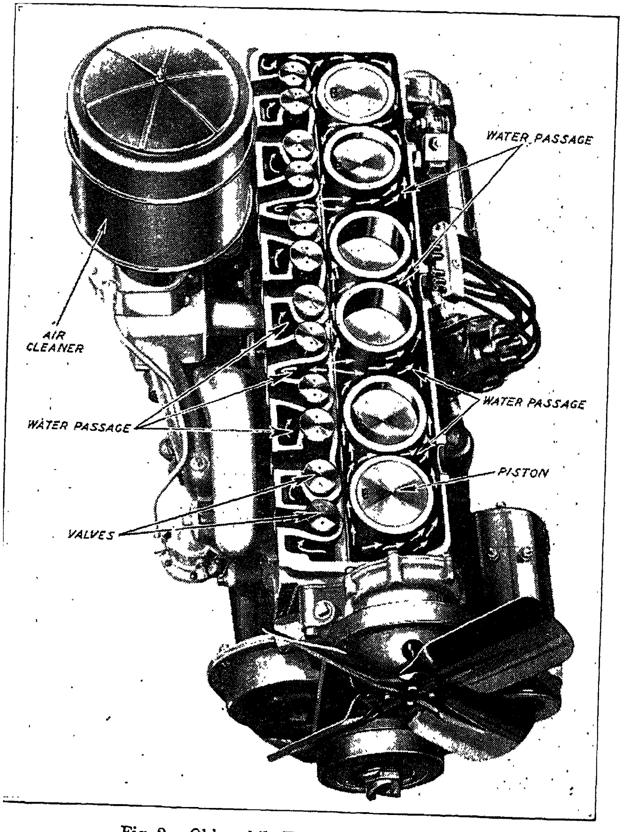


Fig. 2. Oldsmobile Engine Coolıng System
Courtesy of Olds Motor Works

cooling is representative of good design. The water pump which is located at the front of the cylinder block and is driven by the fan belt, is used to discharge water into a manifold tube which lies along the center of the length of the cylinder block in the water jacket. The water distribution manifold tube is on the right side of the cylinder block between the valves and the cylinder barrels. Holes

in the side of the manifold and slots along the top of it distribute the water around the valves as shown in Fig. 2. In this view, the top of the cylinder casting has been cut away so as to show the cylinder barrels with the pistons in them and the valve in their valve ports. It will be noted that the direction of flow of the cooling water is indicated by white arrows. Water thrown into the manifold tube by the pump is coming from the bottom of the radiator, to which point it has settled, as it has been cooled. Heat picked up by this

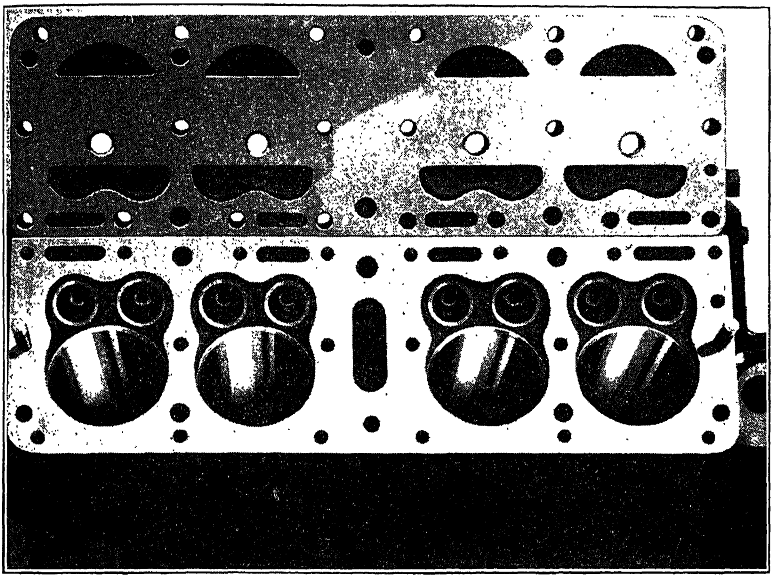


Fig. 3. The Water-Circulating Holes or Ports in the Block and Cylinder Heads Must Meet and Match

cooling water, as it circulates around the cylinder barrels and around the valves, is carried with the water as it rises around these parts and flows off through the manifold at the top of the cylinder head. From the top of the cylinder head, the water is carried to the upper tank on the radiator, from which point it is distributed over the radiator core. As it gradually settles down through the passages of the radiator, it is cooled and again comes to the bottom of the radiator into the lower radiator tank, from which point it is distributed again as indicated above.

Cylinder-Head and Cylinder-Block Joints. When the workman

understands the vital necessity of having the water passages in the cylinder block and cylinder head properly matched and open, he will understand why it is so essential that the proper cylinder-head

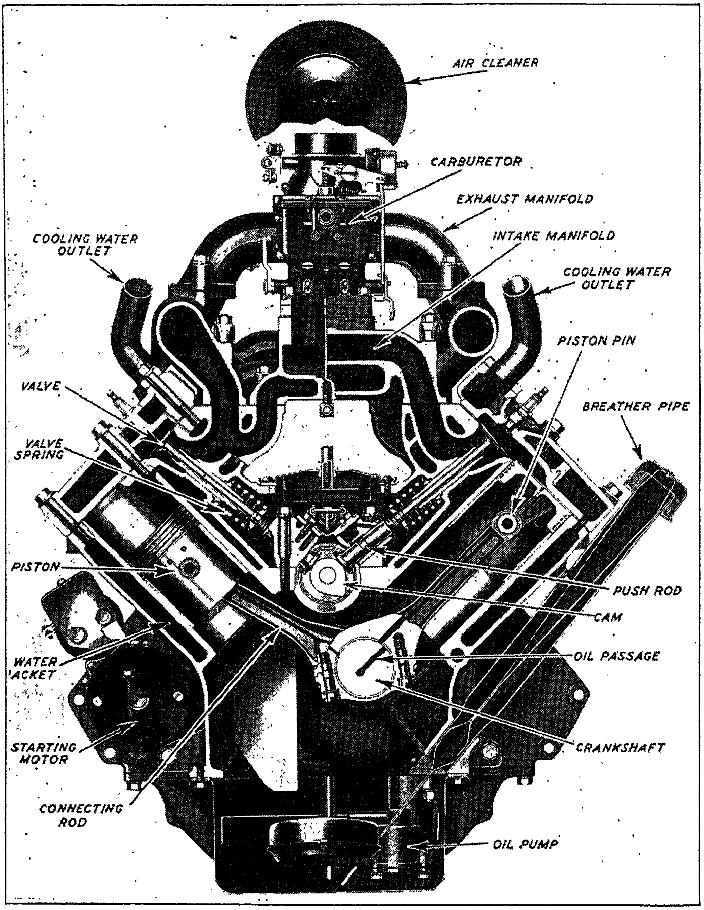


Fig. 4. Cadillac 90° V-8, Series 36-60, 70 and 75 Engine
Courtesy of Cadillac Motor Car Company

gasket be used. It sometimes happens that gaskets are reversed on an engine with the result that part of the water passages may be closed off. In such cases it is impossible for the water which is brought in at the lower portion of the cylinders to circulate up into the cylinder head and thence back to the radiator. Fig. 3 shows the

water circulating holes between the cylinder block and the cylinder head. When studying this figure do not mistake the spark plug holes and cylinder bolt holes for water passages. The water passages are elongated.

Even Temperatures Maintained. The best operating temperature for a water-cooled engine is generally stated as 170° to 190° F. At this temperature the fuels are vaporized in better fashion and the engine operates more evenly due to a better vaporization. Water

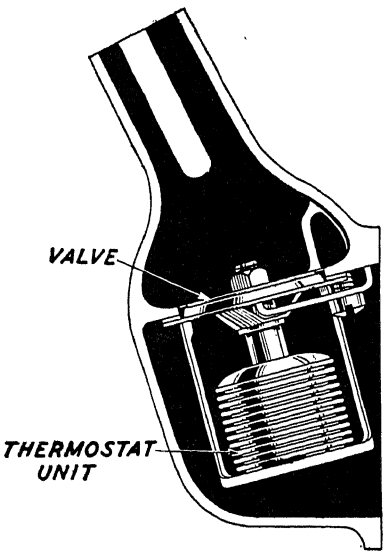


Fig. 5. Cooling System Thermostatically Controlled Valve for Circulation Control
Courtesy of Chevrolet Motor Company

jackets of the V-type Cadillac are illustrated in Fig. 4. It will be noted that the water completely surrounds the cylinders, the combustion space, spark plugs, valves, and the intake and exhaust ports. Not only does the water conduct the heat away from the engine, but it serves to equalize the temperature throughout the engine. The incoming gases will then be warmed in a desirable fashion. This distribution of heat within the engine, owing to the circulation of the water, is a desirable feature since it serves to keep the inner mass of metal evenly heated and allows for even expansion without the

warping of the metal, which would occur if they were not at approximately an even temperature.

Thermostats. Use of thermostat, Fig. 5, within the cooling system is of long standing. Each season has seen the adoption of it as standard equipment by an increasing number of manufacturers.

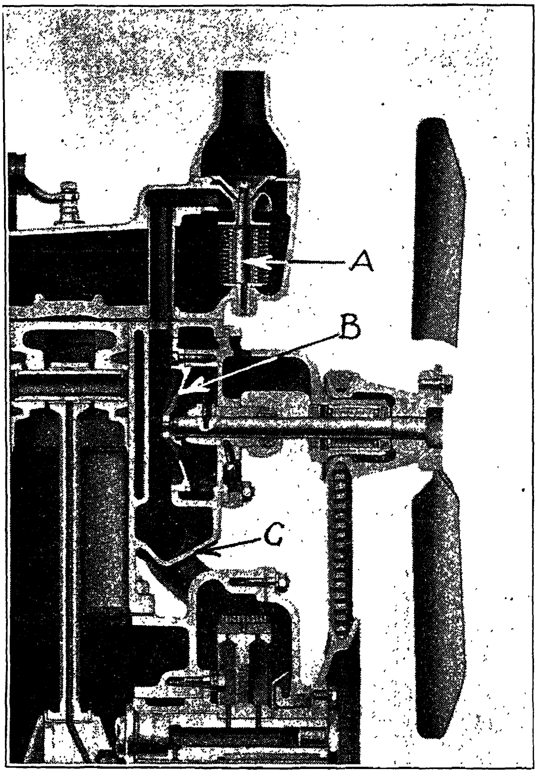


Fig. 6. Fan, Fan Mounting, Water Pump, Thermostat, Water Jackets, and Other Features of the Packard Cooling System

The thermostat shown at *A* in the section of the Packard Motor, Fig. 6, is so designed that it is closed until the water within the engine reaches a satisfactory operating temperature. In order to facilitate the action of the pump and that portion of the cooling solution within the water jacket of the engine, by-passes are made use of so that the water is merely circulated about within the engine jackets and does not pass forward to the radiator until such time

as the temperature of this water is sufficient to open the thermostat. Naturally the thermostat will open rather slowly since the instant it starts to open, cold water is drawn from the radiator and quickly comes in contact with it, thus tending to close it again.

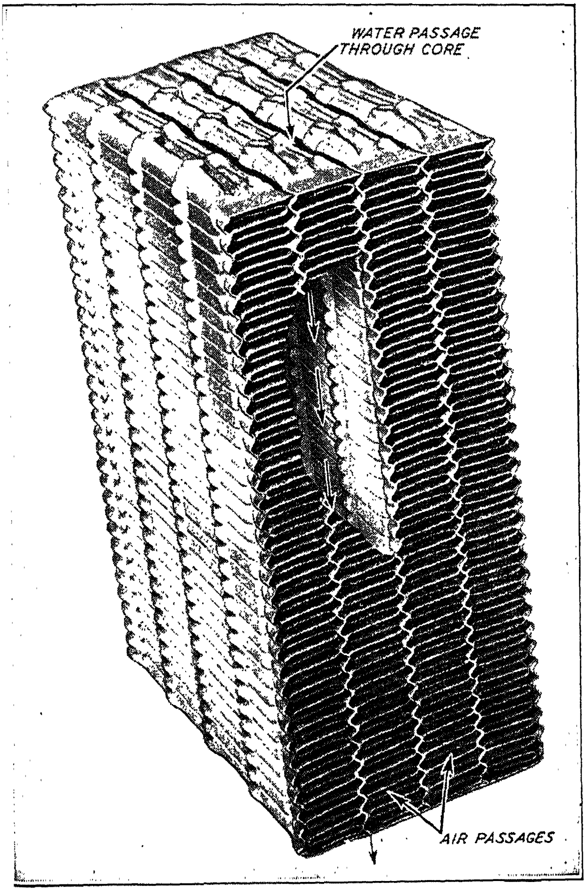


Fig. 7. Cadillac Cellular Radiator Core Section
Courtesy of Cadillac Motor Car Company

It will be seen that the use of the thermostat will allow the engine to warm up much more quickly than if the entire amount of water within the cooling system was circulated as soon as the engine started operating. This is a very desirable feature, since the

crank-case dilution and fuel economy are both involved. This satisfactory engine temperature also allows more prompt operation of the car in a satisfactory manner. This is especially the case when the heavy fuels, now in general use, are considered.

Radiators. Formerly the radiator was made as one unit, that is, the outer surface of the radiator was exposed and became a part of the design of the car. This practice has long since been superseded by the one of constructing the radiator assembly in two parts. The radiator grille is designed to blend in with the general design of the car and may take any form necessary to gain this end. It is usually made of a metal which will lend itself to plating, either nickel or chromium. The part which does the real work of cooling, however, is more properly termed the radiator and while built up of many parts is usually soldered into one unit. In some cases, however, a jacket which is designed to serve as the mounting unit is clamped on to the radiator core.

Cadillac Radiator Core. A section of the radiator core used in all of the current Cadillac models is shown in Fig. 7. It will be noted that the water passages, as indicated by the arrows, are straight and provided with smooth interior, permitting free flow of the water and facilitating the cleaning of the radiator. The fins, which are mounted between the vertical water passages, are of the full bonded construction. Louvers are cut into the fins so as to increase the heat dissipating capacity of the radiator core as the air is drawn or forced through the cooling fin, past the water cells. The material used in the radiator core is all copper.

Round-Tube Radiator Core. The round-tube radiator core was long popular and is representative of the earliest practice. In this case copper or brass tubes are set between upper and lower tanks and in order to facilitate cooling, thin copper fins are assembled upon the tubes at regular spaces. The section of the core shown in Fig. 8 is a full size view of this type of equipment. In order to secure proper cooling, it is quite essential that the thin copper fins be sweated on to the tubes so that the inner core is an integral mass. At one time radiators were built without making use of this method of sweating the parts together, with the result that it was impossible to cool the car.

The simple construction embodied in the style shown in Fig. 8

is substantial and effective. It lends itself to repairs and there is less likelihood of the radiator becoming stopped up since the water passages through the tubes are large.

Pressure Type Radiator Cap. A number of automobiles are making use of pressure operated vent and overflow caps. These caps are provided with a vent valve and a vacuum valve. The pressure operated vent valve is contained in the radiator filler cap. Fluid must pass through this valve in order to reach the overflow pipe. It requires a pressure of about four pounds to open the valve. Owing to this fact, there is less chance of the loss of cooling solution, particularly when the rather volatile anti-freezes are used.

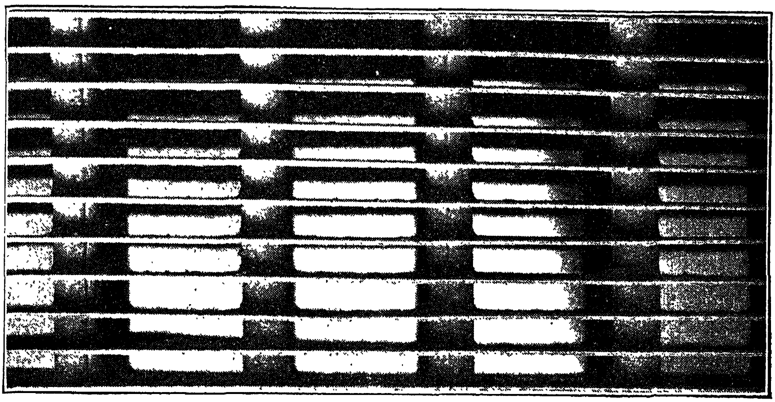


Fig. 8. Section of a Round-Tube Radiator Core

These pressure caps are also valuable in retaining the cooling solution when driving in high altitudes as is the case in mountain driving. At sea level water boils at a temperature of 212 degrees. As the car is driven to higher altitudes, pressure of the air on the water in the system is normally reduced. To offset this pressure reduction and keep the water in the cooling system under a normal or a bit above normal pressure, these caps have been devised. As the pressure of the water within the system comes up to one in excess of four pounds, the vent valve is forced open against the spring which holds it closed normally and excess pressure is relieved through the overflow pipe.

Care must be exercised in removing these caps as there is

danger of being seriously burned when the fluid within the cooling system has come to a vaporizing point. If the fluid is boiling vigorously, it can be heard. When removing the cap from a hot engine, the best plan is to unscrew the cap only part way at first in order

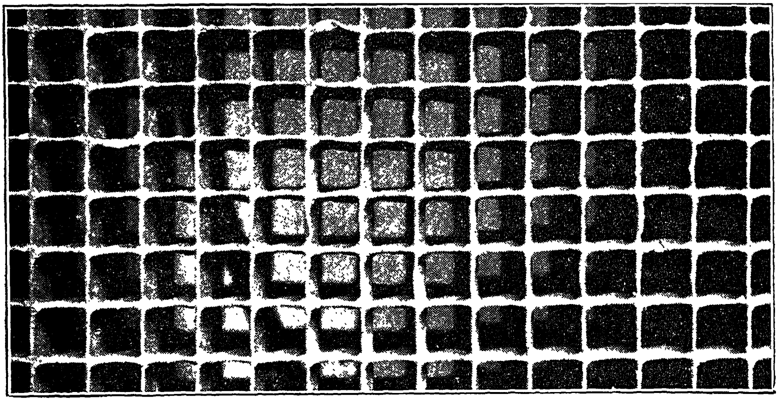


Fig. 9. Section of a Square Honeycomb Radiator Core

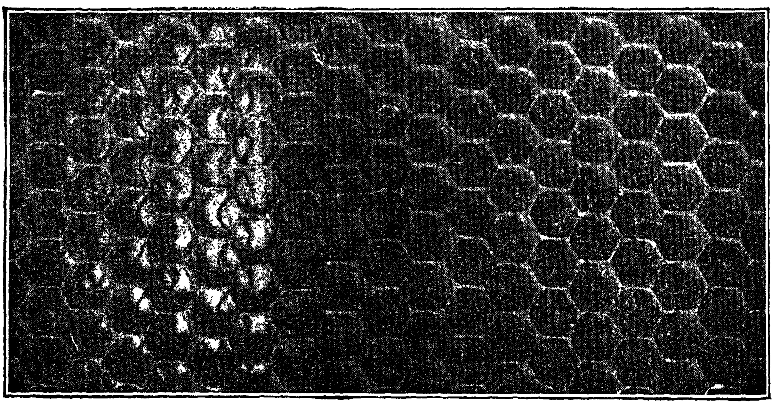


Fig. 10. Section of a Honeycomb Radiator

to vent the system through the overflow. Steam issuing from the overflow pipe will be evidence that this has occurred. Hold the valve in this partially opened position until there is no more steam blowing after which the cap can be completely removed. In the case of an engine which is cool or operating at normal temperature, the cap

may be removed without any danger. To secure the full advantage of this type of cap, it is necessary that it be screwed tight when in use.

Square Honeycomb Core. The square honeycomb is illustrated in Fig. 9. This type of construction makes use of a larger number of tubes which run from the front of the radiator to the rear, the ends being soldered together. When this construction is used, water, which leaves the upper tank, may flow in practically any direction as it is cooled and passes downward. By this is meant that it is not necessary for the water to flow directly down since it may go completely around one of the honeycomb or small tubes.

Honeycomb Radiator. A section of the conventional type of the honeycomb radiator is shown in Fig. 10. This may be of the general type of construction just described, with reference to the square honeycomb tubes or may approximate more closely the use of tubes such as was described with reference to the flat tubes. The honeycomb effect is sometimes secured directly by the use of tubes or by the application of a large number of very fine fins. These fine copper fins are sweated on to the tubes or cells and become a very definite part of the core, serving as conductors of heat to dissipate it into the core.

Cross-Flow Radiator. In practically all cases the radiator makes use of the vertical tube rather than the horizontal tube. The Pontiac cross-flow radiators, used up to 1935, made use of a novel principle, illustrated in Fig. 11. Water which has been heated within the jackets of the engine flows off through the tube *4* in the lower figure. It enters the tube or a similar one at *14* in the upper left-hand illustration. The water which enters at this point comes in contact with other water which is above it. As the water within the radiator is cooled, it does not pass downward but instead is drawn across through the horizontal tubes, as shown in these several figures. While it is flowing across the radiator, it is being cooled and it will then settle in the side tank and be withdrawn from the side tank at *10*. This type of radiator construction does away with a certain amount of loss of water, owing to vaporization. In all cases of water-cooled engine, no matter what the temperature, there is a certain amount of vapor within the upper portion of the upper radiator tank. This vapor is free to escape through the vent tube.

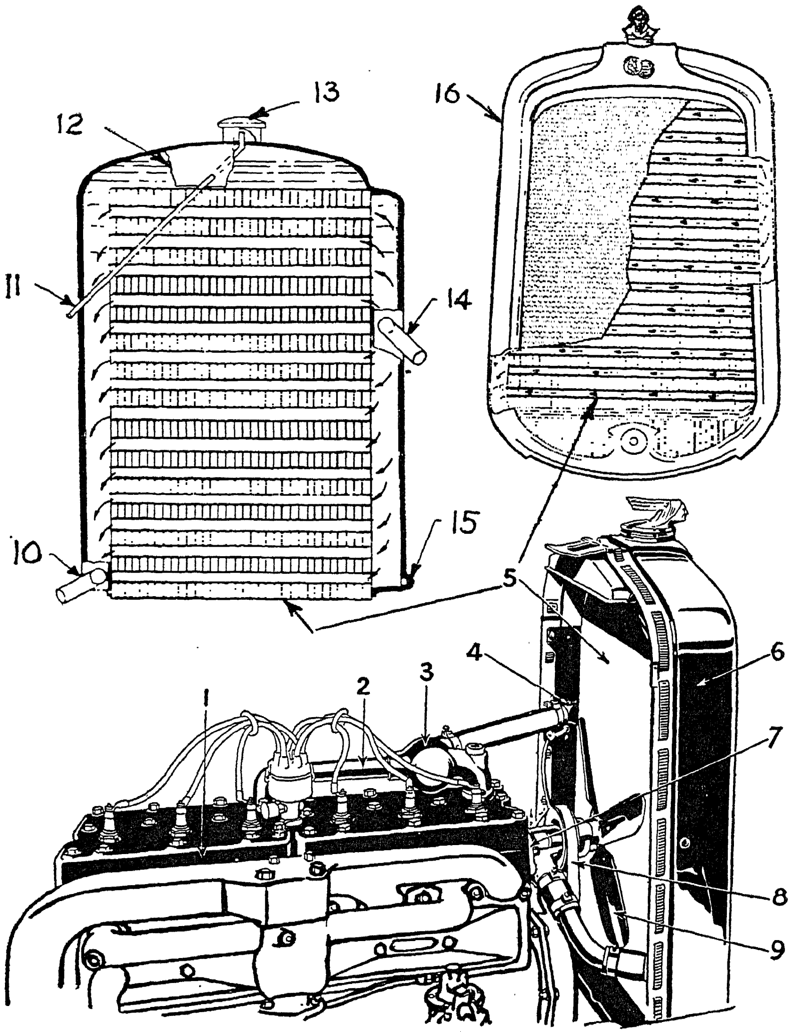


Fig. 11. Pontiac Cooling System with Cross-Flow Radiator

1—Engine Water Jacket. 2—Water Outlet Manifold. 3—Thermostat Housing. 4—Try-Cock. 5—Radiator Core. 6—Radiator Shell. 7—Water Pump. 8—Fan Belt. 9—Fan. 10—Outlet. 11—Vent. 12—Water Level. 13—Filter Cap. 14—Return Inlet. 15—Drain Plug. 16—Front View Partially Sectioned.

Water Pumps. The centrifugal type is of standard design and is illustrated in Fig. 12, as used on Graham "8." At the lower part of the pump are to be found the pet cocks. In all water-cooling systems, a pet cock or pet cocks are provided at low points so that when draining, the entire amount of water may be withdrawn. When draining a cooling system, especially if draining to prevent freezing, it is always well to operate the engine for a time in order to have the pump draw out or free any water which might have

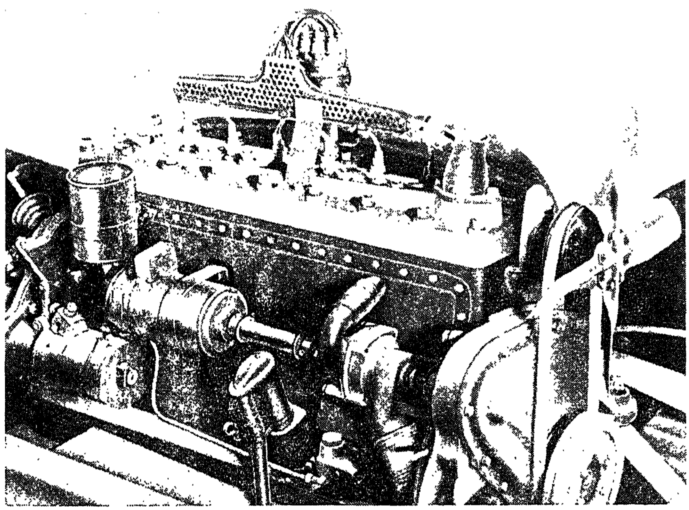


Fig. 12. Centrifugal Water Pump on Graham "8"

been pocketed. This will prevent the freezing of the pump and possibly breakage of parts when attempting to start the engine.

Hudson and Terraplane Water Pump. Fig. 13 illustrates the 1935 Hudson and Terraplane six-vane centrifugal type pump. The pump shaft is mounted on needle bearings, these being used in order to cut down the amount of power required to drive the pump and to insure against overheating and burning out of the pump-shaft bearing through lack of proper lubrication.

Owners who care for the lubrication of their cars are prone to overlook the lubrication of the pump shaft. Student mechanics likewise need to be careful that this point is not overlooked. Each year

many pump shafts are replaced owing to the lack of thought being given to the proper care of this unit. Results of this type of neglect apply equally to all makes of cars.

Ordinary cup grease is not satisfactory for water pump shaft lubrication since it is easily affected by contact with water and tends to lose its lubricating qualities. Manufacturers of the better grades of lubricants have developed special greases for this type of service. Different products are sold under different trade names but the service man is safe if he uses those lubricants which have been especially prepared for this type of service.

Packing a water pump shaft may seem relatively simple to the

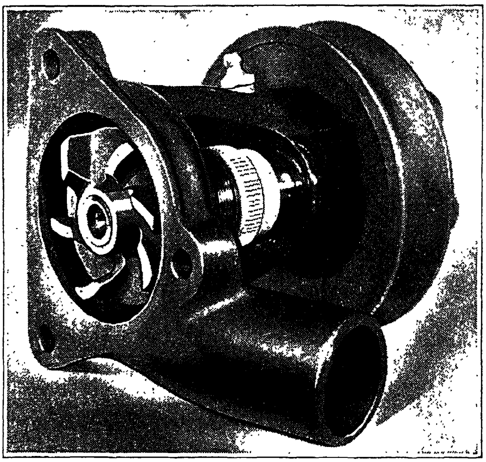


Fig. 13. Six-Vane Water Pump Mounted on Needle Bearing, Used in 1935 Hudsons and Terraplanes

average mechanic but a pump shaft may easily be ruined by an inexperienced workman using a defective packing and unreasonable force on the packing nut and gland. Sometimes the pump shaft is deeply scored by undue pressure on dried out and hardened packing. The packing should be removed, if dry and hard, and new packing installed. This may be either of the plastic or ring type.

Buick Pump and Fan Assembly. The 1937 Buick equipment for both the Series 40 and the larger cars is illustrated in Fig. 14. In all cases, the water pump and fan assembly is mounted on the front

end of the cylinder block. The pump is of the centrifugal type and is driven from a pulley on the crankshaft by means of a V-belt. The Series 40 pump is run at 1.3 times engine speed, while the Series 60 - 80 - 90 pump is driven at 1.1 times engine speed. The pump

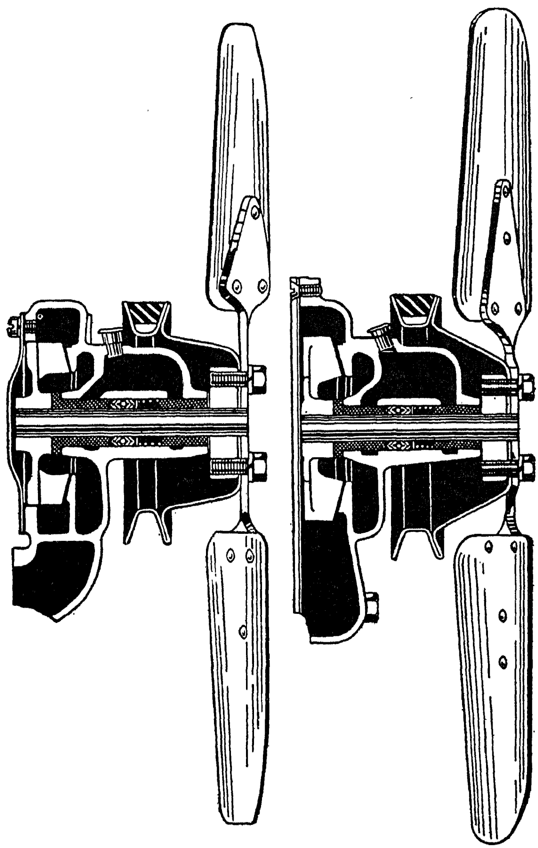


Fig. 14. Buick Water Pump and Fan Assembly
Courtesy of Buick Motor Company

shaft is case hardened and is supported in the pump body by two oil retaining bushings. The lubrication of these bushings is from the oil reservoir which is cast into the pump body and which should be filled with 10-W oil each 1000 miles of service. It is important

that heavier lubricants are not used in the oil reservoir, as this heavy oil will interfere with the normal oil feed through the bushings. The water pump packing is the self-adjusting type and is lubricated through the pump bushing by the lubricant installed during the assembly. If either pump bushing is removed for any reason, it will be necessary to replace both bushings and the packing assembly when reassembling the pump.

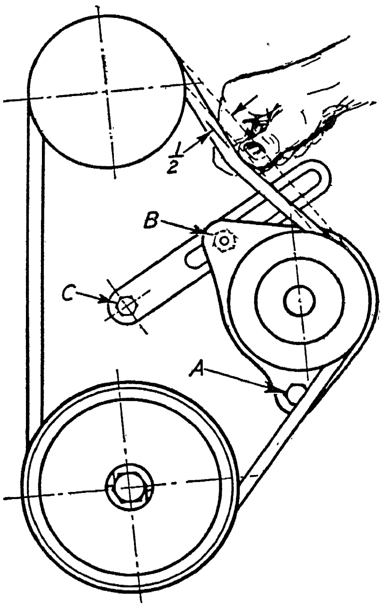


Fig. 15. Buick Fan Belt Adjustment

Buick Fan Belt. A V-type belt, illustrated in Fig. 15, is used as the water pump fan and generator from a pulley attached to the front end of the crankshaft. It is necessary that the belt be adjusted so that it will deflect approximately ½ inch, as shown in Fig. 15. Only a light pressure should be required to secure this deflection. If the belt is too loose, it will slip and wear excessively. The loose belt may also cause a noise similar to a spark rap at high speed. If the fan belt is too tight, the generator and pump shaft bearings will wear rapidly. The Series 40 fan belt is 25/32 inch wide and the Series 60 - 80 - 90 fan belt is 29/32 inch wide.

When adjusting the fan belt, first loosen the lower and upper generator clamp bolts shown at *A*, *B*, and *C*, Fig. 15, a slight amount. Next, adjust the fan belt tensions to ½ inch, as shown, securing this deflection between the generator and fan pulleys. Next, retighten the upper clamp bolts *B* and recheck for tension. Finally clamp bolts *A*, front and rear, and *C*.

Buick Thermostat. The circulation of the cooling fluid within the cooling system of the Buick engine is illustrated in Figs. 16 and 17. The flow of the cooling solution is thermostatically controlled,

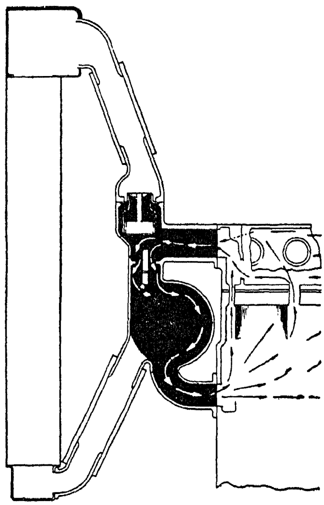


Fig. 16. Buick Cooling System Recirculation

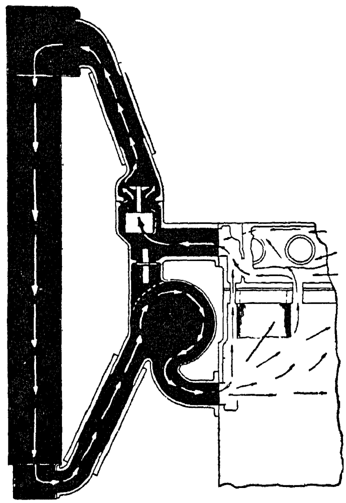


Fig. 17. Normal Circulation in Buick Cooling System

Courtesy of Buick Motor Company

the by-pass type of water temperature control being used. This system permits the water pump to circulate the coolant to the engine during the warm-up period without passing through the radiator, thus allowing the engine to reach its normal operating temperature quickly. This recirculation is illustrated in Fig. 16 where it will be noted that the thermostat permitting water to circulate to the radiator is closed and the water merely leaves the top of the cylinder block and is forced back into the lower portions of the cylinder block water passages. This control is accomplished by means of a thermostat which is located in the passage of the

cylinder head water-outlet and its spring loaded valve located in the water passage between the cylinder head water outlet and the water pump inlet, as shown in Figs. 16 and 17.

The spring loaded valve is somewhat smaller than the neck where it is located and this allows of a fixed orifice. The total area of the orifice is equivalent to a ½-inch hole and permits a thermo-siphon circulating when the engine is not running, cutting down the effect of what is termed "after-boil." "After-boil" refers to the stagnating of the coolant in a hot engine when the pump is not circulating the solution. During the time that the coolant is below normal operating temperature and the engine is running, it is blocked from circulating through the radiator by the thermostat valve. The pump pressure forces the coolant through the by-pass valve and allows the coolant to recirculate through the cylinder block and head, as shown in Fig. 16. When the coolant has reached a temperature of 148 to 153 degrees, the thermostat valve starts to open and the circulation proceeds in the normal way. At approximately 170 degrees the thermostat is fully open, relieving the water pump pressure on the by-pass valve which automatically closes.

Testing the Thermostat. In order to test a thermostat for correct operating temperature, it should be immersed together with a thermometer in a container of water. Agitate the water to insure both water and thermostat being at a uniform temperature. When heating the water, do not allow the thermostat or thermometer to rest on the bottom of the container, as this will cause the thermostat or thermometer to be at a higher temperature than the true temperature of the water. When reaching a temperature of 148 to 153 degrees, the Buick valve should start to leave the seat and be fully open at a temperature not to exceed 175 degrees. This is important as a thermostat which was holding closed, or a sticking by-pass valve either, opened or closed, will prevent the cooling system from functioning and cause overheating.

Radiator Shutters. A great many cars were provided with radiator shutters, which were designed to enhance the operating characteristics of the car. Some of these are manually controlled and some of them thermostatically controlled. The idea of the shutter is to prevent the cold air striking the radiator core until such time as the temperature of the engine has reached a satisfactory

point for economical operation. As the bellows, Fig. 18, absorbs heat from the cooling solution, it expands and forces the bell crank to operate, with the result that the spring tension is overcome and the vertical shutters are opened. The greater the amount of heat, up to a certain predetermined point, the wider the opening of the shutters. When the engine cools, the shutters close. The use of this device proves economical. Not only is fuel saved, but crank-

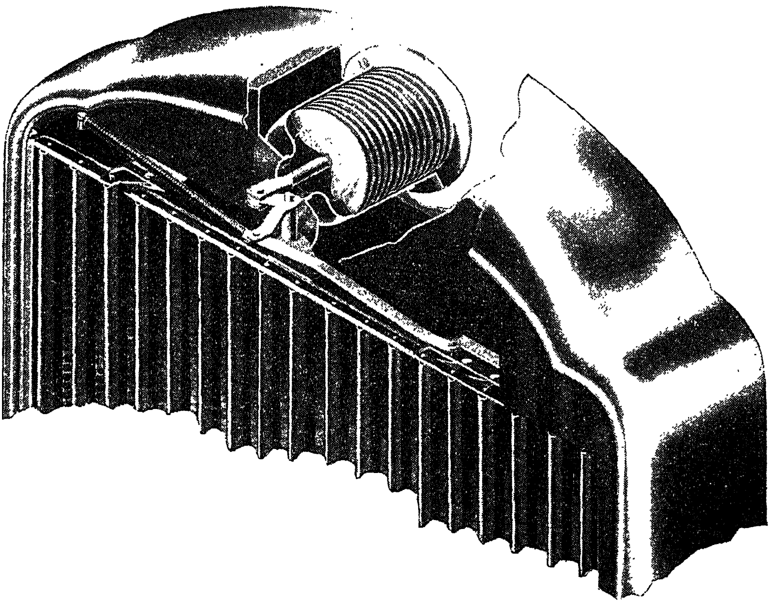


Fig. 18. Buick Thermostatically-Controlled Vertical Radiator Shutters

case dilution is decreased. This, of course, lengthens the life of the engine. The shutters may be in front of the radiator grille or between it and the radiator core.

Cooling-System Service. Cooling systems are efficient only so long as they are free from foreign materials such as, rust, lime, or other elements which might be held in suspension in the water and then deposited in the radiator tubes or cells. The length of time required for a radiator to clog will vary according to the condition under which it is used, for instance, if the water in the community in

which the car is in service is filled with lime or other foreign elements, the sediment will settle or collect within the tubes rather rapidly.

Handling the Radiator. Many repair men experience trouble with radiators which to all intents and purposes come about when the car is in the garage for service. This is usually due to the fact that when the radiator is removed from the car after a job such as valve grinding and carbon removing, it is set aside and allowed to dry out. In certain cars this is a condition to be looked for and avoided by seeing that the radiator is properly flushed before it is set aside, or else the radiator should be kept filled with water. Rust, lime, or scale are usually causes for the radiator clogging.

Boiling Out a Radiator with Sal Soda. Cars which have been in service for a while are likely to be in need of having the radiator cooling system boiled out so as to clean the radiator and secure efficient cooling. This is a situation which might arise at any time, but a good time to give it attention is when the cooling system is being serviced for the winter months, and then again in the spring when the car is being serviced for summer driving.

First start the engine and operate it until the water has come up to a normal operating temperature, then open the petcock and drain off the water. Prepare a solution of sal soda—one pound soda to five gallons of water; next fill the cooling system with this solution, after which the engine should be started and operated until the solution has come to approximately the boiling point. Run the engine with the solution in the cooling system for a short time, stop the engine, allow it to set for a few minutes, then drain off the cleansing solution. Flush the system with clean water so as to remove any trace of the cleansing solution.

Sal soda, which is the common washing soda, is a caustic solution and will destroy any paint it comes in contact with. For this reason it is very necessary that **extreme care be used to see that none of the cleansing solution comes into contact with the paint or finished parts about the hood of the car.** Keep the radiator cap on tight while boiling out the system.

Flushing a Normal Cooling System. When servicing the cooling system of a car which has shown any tendency of overheating, all that is necessary is to flush the system as shown in Fig. 19. It will be noted in this case that any petcocks such as those in the radiator

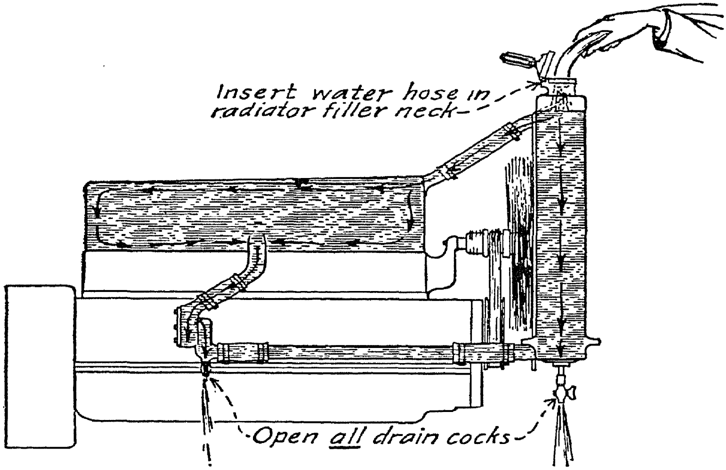


Fig. 19. Ordinary Method of Flushing the Cooling System

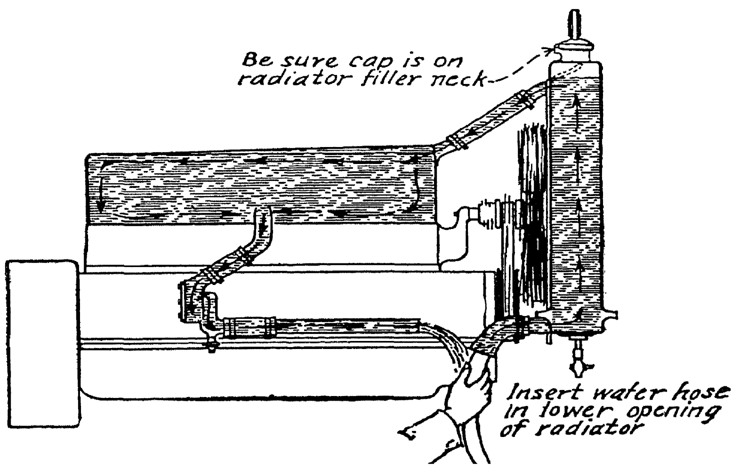


Fig. 20. Flushing the Cooling System from the Bottom of the Radiator to Remove Rust and Scale

or pump are open. The water hose is inserted in the top of the radiator. Water flows down through the system and washes out any small amount of sediment or rust.

Flushing a Rust-Clogged Radiator. This work is done as shown in the illustration in Fig. 20, where it will be noted that the hose connection has been removed from the lower gooseneck or hose connection. The cleaning water now flows from the bottom of the radiator up through the radiator and then through the water jacket, and finally through the pump, and is wasted from the end of the hose

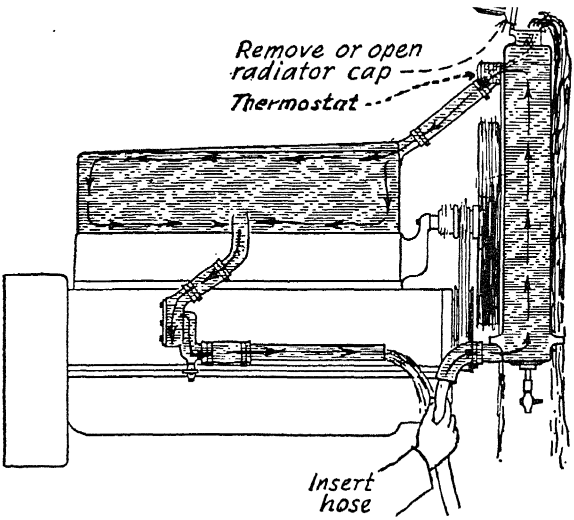


Fig. 21. Flushing a Rust- and Scale-Clogged Cooling System Which Is Fitted with a Thermostat

which is removed. It will be noted that this causes the water to flow through the cooling system in the direction the reverse of the normal one and thus serves to break up some of the scale and rust deposited.

Flushing a System with a Thermostat. The thermostat may be in the upper line or hose connection as shown in Fig. 21. The thermostat is open only when the temperature of the cooling system reaches a certain predetermined point. If cold water is used for flushing, it will not cause the thermostat to open, with the result that one or two things must be done. Possibly the best plan is to

allow the radiator cap to remain open and flush from the bottom up to remove the sediment accumulated in the radiator. If hot water is used, the radiator cap may be left open, but the action of the hot water will cause the thermostat to open so that more of the hot water will flow through the water jacket and water pump. Another method of flushing the block is to use the cold water and open up the top hose so that the water may be introduced, as shown in Fig. 22.

Using Air and Water as a Flushing Combination. A small amount of air under pressure may be introduced into the water which

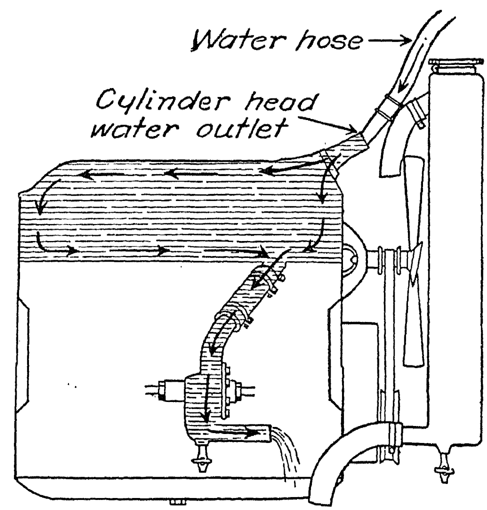


Fig. 22. Flushing Out the Water Jackets of the Cylinder Block

is used for flushing the cooling system. The pressure of the air must not exceed 10 or 15 pounds, since the radiator core will not stand any heavy pressure. When the air jet is used in connection with the water, an air nozzle is set into the lower hose, along with the water hose. If considerable radiator flushing is being done, the workman should provide himself with a combination nozzle.

The advantage of using the air lies in the fact that water and air combined, when sent through the radiator in spurts, has a much greater loosening and cleansing effect. Accordingly, when this com-

bination is used, the water is allowed to flow for a short time, and then the air is introduced for a short time with it, and then closed off. Spurts of air are used rather than a steady flow.

NOTE: In the large centers there are radiator cleaning establishments. These are in connection with repair stations. They make use of special compounds when boiling out radiators. The nature of these compounds may be learned by getting in touch with local distributing agencies or automotive jobbers.

Tightening the Cooling Systems. The loss of a small amount of water is usually of slight concern to the car owner. On the other

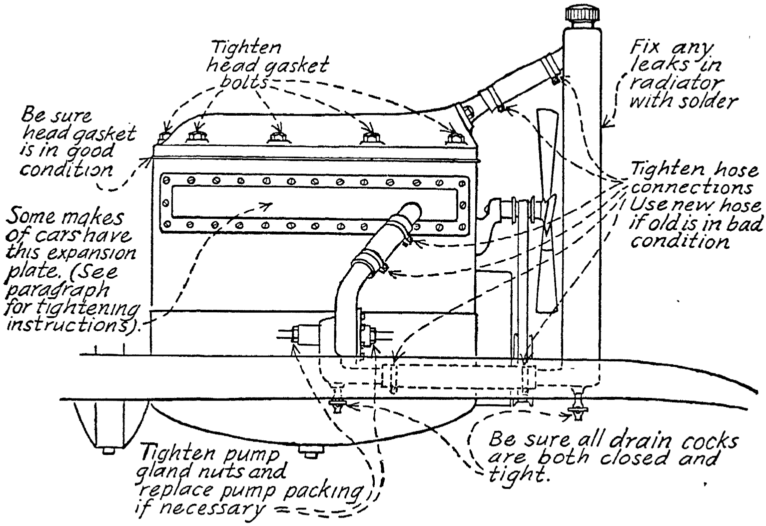


Fig. 23. Service Chart Illustrating Parts of a Cooling System Requiring Tightening and Servicing for Anti-Freeze

hand, when a car is serviced with an anti-freeze, some of which are very expensive, the customer is very anxious to know that the solution which he pays for is going to stay in the cooling system. Some of these solutions are harder to hold in the cooling system than water. Fig. 23 illustrates the points which require attention when tightening up the cooling system. These are the cylinder head bolts, expansion plate screws, the hose bands, petcocks, and the water pump bushings.

Radiator-Hose Troubles. Fig. 24 illustrates the most ordinary type of radiator-hose failure. The two hose sections shown at the lower part of the illustration have been photographed from the end. It will be noted that the one at the left has had the inner lining curled until the passage is almost entirely clogged. The one at the lower right is not in such an advanced stage of deterioration. The view at the top is of the same hose as the one at the lower right. When

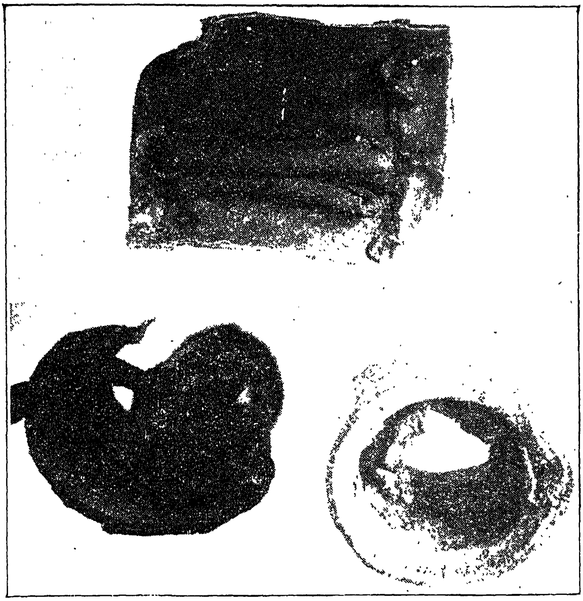


Fig. 24. Radiator Hose in This Condition Will Cause Overheating

hose connections are in such condition, the cooling solution is almost blocked and overheating is certain.

The most troublesome point about a cooling system is with the hose band and hose-end connection, where leaks are prone to develop. While this is a small matter, it may result in serious damage if the owner is not aware of it. The service man should use care to see that these small leaks are stopped. When long connections are used between the radiator and the pump, they should be supported to prevent their collapsing when the engine is under speed. These connections are the ones at the lower part of the power plant and

very frequently are almost out of sight. The best practice is to make use of a section of steel or copper tubing and two short lengths of hose if there is considerable distance between the pump and the radiator. This is not always done, however, and the suction of the pump on the hose will cause it to flatten out or collapse, especially if the radiator has become partly clogged. Once it collapses, no portion of the water can get through and serious overheating results. When the mechanic looks for the trouble, the engine may be stopped or idling and the hose will have assumed its normal condition, all of which makes it hard to locate the trouble which may not be suspected. An easy cure for trouble of this kind when found is to place a coil spring, such as a valve spring, within the hose to prevent it collapsing.

The effects of anti-freeze on hoses may result in a condition similar to that shown in Fig. 24. Most anti-freezes are not detrimental to hose connections; however, any of the anti-freezes will have a certain effect in hastening deterioration. Oil within the radiator will cause the hose lining to become softened and rot, which will result in the curling.

Cooling systems are serviced in the fall when the anti-freeze is added and again when the anti-freeze is removed. It is a good plan to sell your customers on the idea that it pays to have the hose connections renewed at these intervals and no trouble is likely to develop in the meantime.

Servicing a Water Pump. The packing glands on the sides of the water pump may be provided with means for lubricating or not. When they are so provided, the grease cup should be kept filled with a high grade of graphite or other grease suitable for use in such work. When no grease cup or alemite fitting is provided, it is assumed that the packing will have graphite in it which will be sufficient for the life of the packing. This is not always the case and leaking may result even though the packing nut is drawn up from time to time. A good plan is to remove the old packing and replace it with new.

Packing comes in two forms—the most usual being the roll of packing cord, properly graphited, which may be purchased from the jobber and should always be on the shelf of the service station stockroom. Another form, which is more satisfactory when it can be obtained, is the packing ring. These are made in sizes corresponding

to the engineering specifications for the popular cars. They are provided with a bevel split so they may be twisted apart, slipped over the shaft, and installed within the packing gland under the nut.

The most serious mechanical failure which is common to water pumps is that of the pitting and scoring of the pump shaft where the pump packing has been compressed on it. The corrosive effects of the water and the scoring of the packing result in rapid wear. In many instances this occurs where no grease cup has been provided or where the greasing has been neglected. The best remedy is to have the pump shaft removed and replaced with a new one. The customer is not always willing to meet this expense. In such cases, the following treatment is recommended for the rough and pitted shaft.

Plastic Packing. Where the pump shaft has been scored and pitted so badly that it is impossible to keep the packing tight, the use of a plastic packing is recommended. These may be secured through the automotive jobber. The trade name of one of these is "Konaugh." This is a composition packing which may be pressed into the pump gland housing with the thumb and forefinger or by means of a small tool. When using this, it should be inserted and then the gland nut pulled up quite tight and the engine operated or the car driven for a few miles, after which the gland nut may be taken up again to compensate for the filling of the grooves by the plastic packing. After the above treatment, be sure to lubricate the job with a proper grade of grease. Owing to the heat surrounding the pump, the ordinary chassis lubricating grease is readily dissolved and carried away. Possibly the best grease is the tallow base grease or some of the specially prepared greases, which may be secured through the supply houses.

Loose or Worn Impellers. The impellers which are used in the centrifugal type pumps on the side of the engine are usually larger than those mounted within the cylinder block at the upper front and driven from the fan pulley. The latter is more likely to fail, due to end thrust, which causes the flanges of the impeller to be worn off to a point where no pump action is secured.

One of the most common causes of failure is freezing, resulting in sheared keys and broken pins, which allow the pump impeller to loosen on the pump shaft. This condition is one of the reasons that

manufacturers are using flexible means for driving the pump shafts, such as the fan-belt drive. Many cases of broken timing gears are reported each year, owing to the fact that the water pump has frozen and the starting motor is used in an attempt to start the engine. When overheating is experienced, the pump impeller is always to be suspected. It may be necessary to disassemble the job to make sure that it is in proper condition.

Overheating Causes. The causes of overheating have already been treated and will simply be enumerated here. The most common ones are dirt, rust, or scale, which accumulates in the radiator, oil which has entered the cooling system, hose failure, failure of the thermostat, usually due to loss of liquid within it, loose fan belts, broken fan belts, dry fan-shaft bearings, low water supply, use of anti-freeze in the hot months, faulty water pump, dirt and insects in the air passages of the radiator core, an overloaded car, and brakes which are set or dragging.

COMPARATIVE TABLES OF DENATURED ALCOHOL AND DISTILLED GLYCERINE

Loss of Anti-Freeze Properties

Per Cent by Volume	Glycerine Boiling Point Degrees F.	Per Cent Glycerine in Vapors	Alcohol Boiling Point	Per Cent Alcohol by Weight in Vapors
10	214	0	199	49
20	216	0	190	64
30	217	0	187	71
40	221	0	183	76
50	225	0	181	80

PREPARING ALCOHOL OR GLYCERINE ANTI-FREEZE

Per Cent by Volume of Alcohol or Glycerine Solution

Where the Lowest Temperature to be Expected Is	Use a Solution of the Following Per Cent by Volume
20° above zero	15
10° above zero	25
0° zero temperatures	35
10° below zero	40
20° below zero	45
30° below zero	50

Anti-Freeze. The three most popular anti-freeze solutions are —denatured alcohol, radiator glycerine and Eveready Prestone. Each has its own peculiar advantages. It is not within the province of this treatise to rate one as superior to another, rather to set forth the advantages of each so as to allow the student mechanic to present the relative merits to his customers. No one knows what the developments of the next season may be.

Alcohol. Alcohol is the cheapest of the three in point of initial cost. It is an excellent anti-freeze, mixes readily with water, remains in suspension, and is to be had at all points. Its disadvantage lies in the fact that it will boil away readily and also in the fact that it will affect the finish of the car if it comes in contact with it.

Radiator Glycerine. This is a form of alcohol and is quite similar to the glycerine of household use. It is produced by distilling crude glycerine and condensing the glycerine vapors. It has a boiling point which is quite high. When mixed with water, it has a higher boiling point than the water itself, as will be noted from the study of the comparative table shown herewith—comparing the relative loss of the denatured alcohol and distilled glycerine at various boiling points and in certain percentage of volume.

Eveready Prestone. Eveready Prestone is a trademark for a colorless, odorless liquid which is used in the preparation of anti-freeze solutions. It is a distinct chemical compound and as it comes to the service station is undiluted with water. Some points claimed for it are the following: When used in the percentages recommended for preparing the solution, it will give protection against freezing. It does not boil away, having a higher evaporating point than that of water. It will not affect any of the parts of the cooling system and it has a satisfactory heat coefficient so that the motor will not overheat. It is claimed that it does not affect the car finish and is not inflammable. Perhaps the only objection to it is the initial cost, which is high.

Servicing a Car with Alcohol. Prepare the cooling system by having it drained, flushed, tightened, and going through the steps an inspection of the cooling system may indicate need of. Determine the capacity of the cooling system by inspecting a chart which will be furnished by the automotive jobber or the distributing agency which furnishes the alcohol. Determine the point to which

the car is to be protected, as near as possible. Drain off sufficient water so that the amount of alcohol to be added may be added without causing the radiator to be filled. Finally fill the radiator with water to a point two or three inches below the top of the upper tank, Fig. 25. If no other chart is at hand, the following one will serve as a guide. It must be remembered that while a small amount of alcohol will prevent solidifying of the solution, ice crystals will appear at a much higher point.

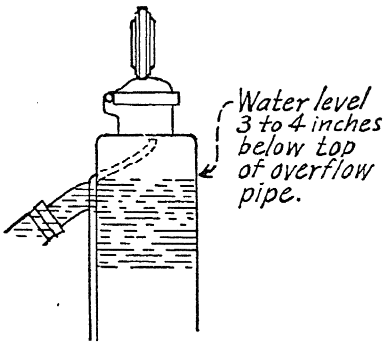


Fig. 25. Keep the Liquid Level in the Radiator 3 to 4 Inches Below Top of Overflow Pipe

FREEZING POINTS OF ALCOHOL AND WATER SOLUTIONS

Per Cent Alcohol by Volume	First Crystals Appear at
10	27° above zero
20	19° above zero
30	10° above zero
40	2° below zero
50	18° below zero

FREEZING POINTS OF GLYCERINE AND WATER SOLUTION

Per Cent Distilled Glycerine by Volume	First Crystals Appear at
10	29° above zero
20	21° above zero
30	12° above zero
40	0° at zero
50	15° below zero

Servicing a Car with Radiator Glycerine. Prepare the system, being very careful to see that all joints are secure and tight. Radiator glycerine has the so-called habit of creeping, that is, it will follow along any joint and, unless the cooling system has been most carefully serviced, it may find its way through a joint. There is no particular objection to this except for the fact that the radiator or the joint at which it appears will seem to be leaking all the time. As a matter of fact, very little solution is being lost; but since the radiator glycerine does not evaporate, it seems that the leak is more serious. The chart on page 32 shows the percentage by volume of distilled glycerine to use in order to secure protection to certain temperatures. For instance, the first crystals will appear in the glycerine and water solution when the temperature has fallen to zero in the case of a solution of 40 per cent glycerine and 60 per cent water. Since glycerine is not boiled away, a larger percentage may be used when servicing the car for the winter. In fact, if everything is tight, there is no need for continually adding glycerine to the solution since the glycerine is not boiled away. Glycerine radiator solutions as put on the market may be already diluted with some water.

AMOUNT OF EVEREADY PRESTONE TO USE FOR PROTECTION TO TEMPERATURES INDICATED
(In Gallons)

Capacity of Cooling System	10 Degrees above Zero	Zero	10 Degrees below Zero	20 Degrees below Zero	30 Degrees below Zero
2	½	. . .	. . .	. . .	1
2½	. . .	. . .	1	. . .	1½
3	. . .	1	. . .	. . .	1½
3½	1	. . .	. . .	1½	2
4	1	. . .	1½	. . .	2
4½	. . .	1½	. . .	2	2½
5	1½	. . .	2	. . .	2½
5½	1½	2	. . .	2½	3
6	1½	2	2½	. . .	3
6½	2	. . .	2½	3	3½
7	2	2½	. . .	3	3½
7½	2	2½	3	3½	4
8	2	2½	3	3½	4
8½	2½	3	3½	4	4½
9	2½	3	3½	4	4½
9½	2½	3	4	. . .	5
10	2½	3½	4	4½	5

Servicing a Car with Eveready Prestone. As in the case of the glycerine, the Eveready Prestone does not require more than one servicing for the season. For this reason, make very certain that all parts of the system are tight and are kept tight. The solution is expensive, but when considered over a season the cost is warranted. It is unwarranted if the customer has to replace the Prestone owing to a defective job of servicing. As in the case of the glycerine, the boiling point is high and if any solution is lost outside of actually being spilled or leaking from the system, it is the water rather than the Prestone, and only water need to be added. The chart on page 33 shows the amount of Prestone to be added to a cooling system in order to secure protection. Since the solution is sold only by gallons and half-gallons, smaller amounts are not considered in making up the chart and in some cases the protection will run lower than that of 30° below zero. Fill the cooling system to 3 inches from the top of the overflow pipe. This allows for expansion of the solution without loss.

Testing the Strength of the Anti-Freeze Solution. Hydrometers, Fig. 26, are supplied to test the density of any of the three popular anti-freezes. These are very similar to those used for testing batteries. The workman doing the job should make certain that he understands exactly how to read the tester. Not all makes are read the same. The storage battery specific gravity hydrometer may be used for testing the distilled glycerine solution. The reading will be according to the following chart:

If the solution is hot 160° F Specific Gravity will be	PROTECTION TO	If the solution is cold 32° F. Specific Gravity will be
1.063	+10° F.	1.094
1.0835	0° F.	1.1175
1.1015	−10° F.	1.137
1.114	−20° F.	1.152

Watch Radiators and Heat Indicators in Winter. In order to prevent the loss of any of the cooling solution in the winter, customers should be instructed to give particular care to the temperature of the cooling solution and not allow it to exceed that which will prevent the boiling away of the water in the case of the glycerine or Prestone solutions or the boiling away of the alcohol

in the case of its use as an anti-freeze. Alcohol will boil away at a temperature as low as 180°, water of course, at 212° F. It sometimes happens that the automatic radiator fronts fail. This is likely to be the case where the front has been stored during the summer and is again installed as the customer's car is serviced for the winter. The chemical solution within the thermostat bellows may have become lost and no action will result as the job is heated. This may happen at any time in the life of the shutter.

Danger of Driving without Anti-Freeze. Since many cars are equipped with thermostats, it is essential that customers be

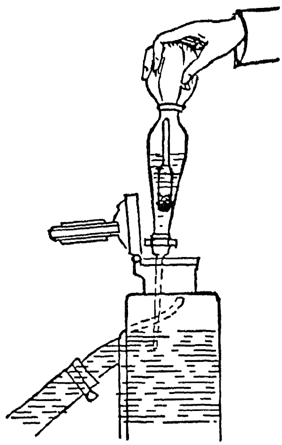


Fig. 26. Anti-Freeze Solution Should Be Tested Weekly

educated to the fact that it is a dangerous practice to drive a car in the cold winter months without some form of anti-freeze. Formerly the practice was indulged in by many motorists to drain their cars in the evening. Even that has long since proved poor economy since, in many cases, the owner who thought he had drained his car found that water had pocketed at some point and a bursted cylinder or valve port was the result. This practice is even worse when the car is equipped with a thermostat. At *A*, Fig. 27, it will be noticed that the thermostat which is built into the radiator and water line, is closed and at *B* it is open. These thermostats are so designed that they will not open until the temperature of the water

has reached approximately 120°. Up to this point circulation through the radiator is prevented.

Tighten the Fan Belt. For many years the flat fan belt was used in the majority of cases. The fan mounting was so designed that by loosening a clamp screw the fan pulley assembly could be swung upward and thus the fan tightened. With the advent of the practice of building the fan and water pump in a unit assembly, it was found necessary to devise other means of tightening the belt, which in most cases is of the "V" type.

The "V"-type belt and pulley has an inherent advantage in that the greater the strain on the belt, the more closely and tightly

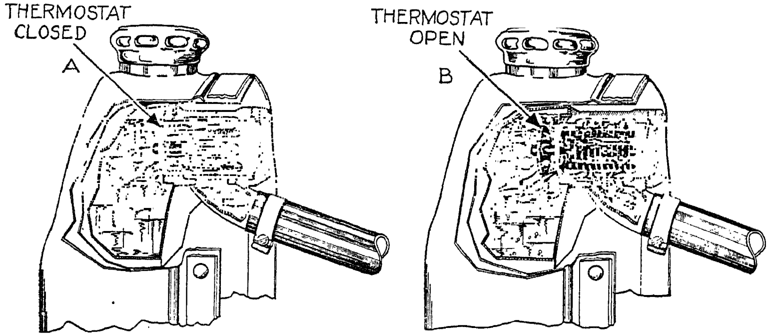


Fig. 27. How the Thermostat Controls Radiator Solution Circulation

the belt will be pulled into the pulley groove. On the other hand, the belt might become so loose that no action will result. In many cases the tightening is affected by means of a split fan-belt pulley. By loosening several screws, a portion of the pulley may be turned sideways and a cam or eccentric action secured which throws the two halves of the pulley closer together, resulting in a tightening of the fan belt, owing to the fact that the size of the pulley is increased. In other cases the "V"-type fan belt is tightened by means of a generator adjustment, as is the case with the Chevrolet "Six," the Ford Model "A," and others. By loosening the generator, Fig. 28, and swinging it to the side, proper tension is placed on the fan belt, which serves as a fan and generator drive. It is not necessary to have the "V"-type belt running as tight as a flat belt. Use care when adjusting the fan belt not to have it too tight.

A-C Thermo-Gauges. The A-C thermo-gauges are used in connection with the automobile engine so that the driver of the car may know the operating temperature of the engine. These thermo-gauges are in reality heat indicators. The principle of operation is quite similar to that of any pressure gauge. However, in this case there are three individual parts of the installation. One of these is the gauge itself which is mounted on the instrument panel. Another one is the bulb which is necessary as the unit in which the pressure is developed by the heat of the water in the cylinder jacket, and the third unit is the capillary or small metal tube which is used to connect the bulb to the Bourdon tube of the gauge.

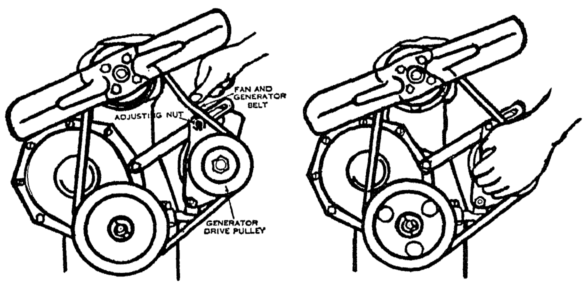


Fig. 28. Adjusting the Chevrolet "Six" Fan Belt by Moving Generator Outward

The gauges themselves are made in two types, either the gearless type or the gear type. In the gear type the regular and heavy-duty gauges are regularly produced. The gearless type is illustrated in Fig. 29.

The thermo-gauge bulb is illustrated in Fig. 30. In this figure, three sizes of bulbs are indicated—the small, the medium and the large. The distance from the gauge to the bulb installation, that is, the length of the capillary required, determines the size of bulb to use. Another feature entering into this is whether the gauge is of the gearless type or whether it is of the gear type. A smaller bulb is recommended for the gear type, because of the smaller amount of motion of the Bourdon tube required to move the pointer the same number of graduations on the face of the gauge.

It will be noted that in Fig. 29 the Bourdon tube has one hand anchored and the other one is free to move so that as it moves under

the pressure from the bulb liquid as it is vaporized, it in turn pulls the connecting link, causing the pointer crank mechanism to move the pointer.

A highly volatile liquid is placed in the thermo-gauge bulb so that as the water of the engine is warmed by the operation of the engine, it is vaporized and a pressure is caused to flow through the

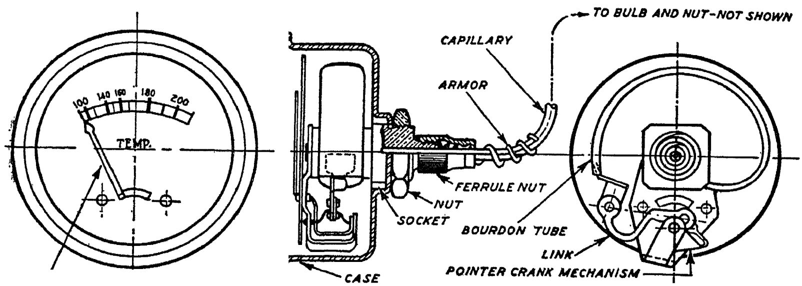


Fig. 29. AC Thermo Gauge
Courtesy of AC Spark Plug Company

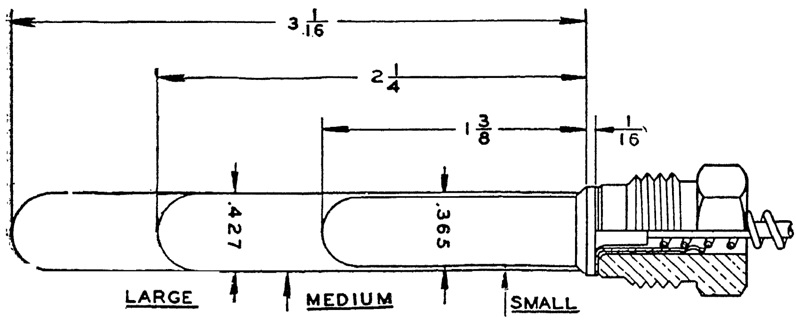


Fig. 30. AC Thermo Gauge Bulb

capillary to the Bourdon tube. The greater the heat in the engine the greater the pressure within the tube, and the more movement of the pointer.

Most service men will never have need of engineering the A-C equipment into a job not previously supplied. When equipment fails, of course, replacements of identical equipment are always safe. The service man might be interested in knowing that the small gauge bulb installation is used with the gearless type gauges when

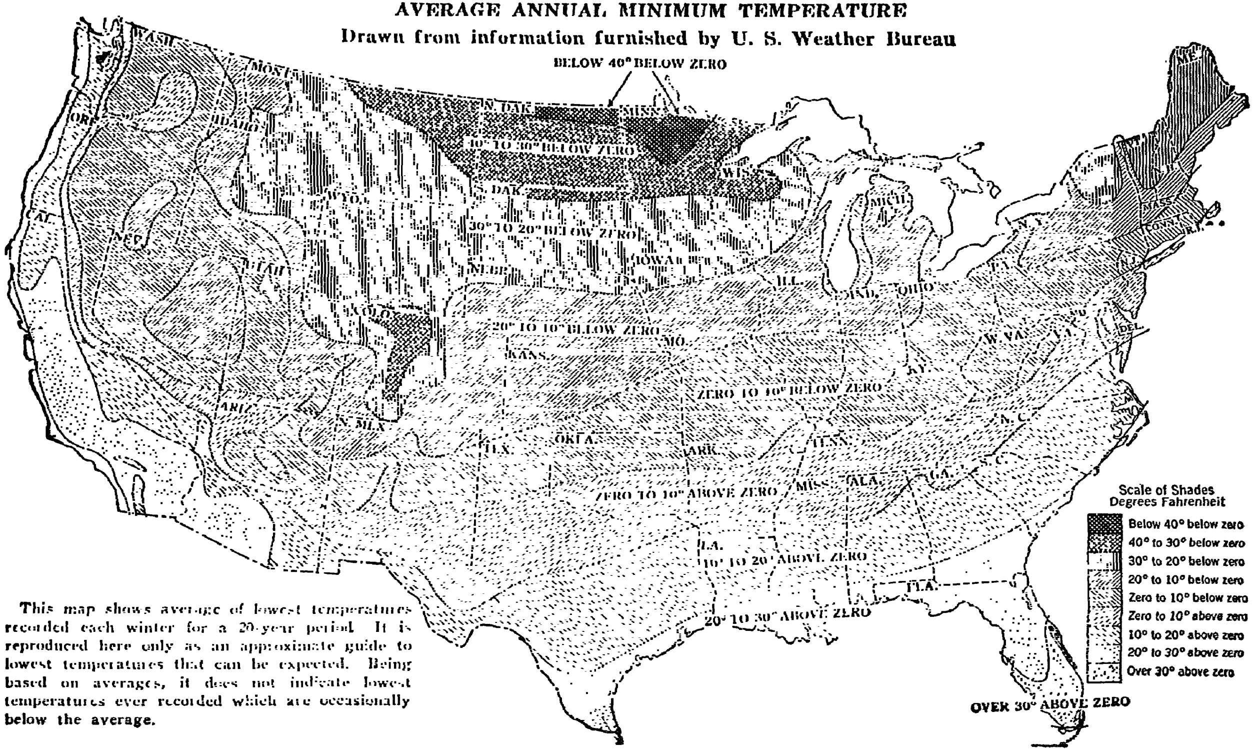
the capillaries are not more than eight feet in length. A medium bulb is used with the gear type gauge when capillaries are not longer than eight feet and on all heavy-duty gauges with capillaries up to twenty feet. The large bulb is used with the heavy-duty gear type gauges when capillaries run from twenty to thirty-five feet in length.

One of the most common difficulties encountered in servicing these thermo-gauges has to do with the installation of car heaters and the removal of car heaters. For the bulb to operate properly, it is necessary that it be introduced into a position in the water jacket where the heated water is flowing around it. This, naturally, is done by the engine manufacturer. However, when the service man installs a heating unit, he sometimes has occasion to move this bulb with the result that not the same heating effect is secured with reference to the device. This may result in a temperature reading which is less than actually exists in the engine. As a consequence this may lead to a false sense of security on the part of the operator of the car, since he believes that his engine is actually operating at a temperature many degrees below that which exists.

Ordinarily no difficulty is encountered with this equipment unless the hot water heater is cut off by closing off a valve so as to prevent circulation of the water. In some cases difficulty is encountered when the service man disconnects the hot water heater and leaves the thermo-gauge bulb sticking out in a length of pipe where no water is circulating around it. In all cases the bulb should extend into the water which is circulating and approximately ⅛ inch of area should be available for this circulation at all points around the tube. Never permit the thermo bulb to be installed in a hot water pipe or tube in which the water is not circulating.

AVERAGE ANNUAL MINIMUM TEMPERATURE

Drawn from information furnished by U. S. Weather Bureau



This map shows average of lowest temperatures recorded each winter for a 20-year period. It is reproduced here only as an approximate guide to lowest temperatures that can be expected. Being based on averages, it does not indicate lowest temperatures ever recorded which are occasionally below the average.

A MAP WHICH PREDICTS ANTI-FREEZE SALES AND SERVICE DATES FOR YOU

Courtesy of National Carbon Company Incorporated

COOLING SYSTEMS

BUICK RADIATOR AND GRILLE DESIGN

The constant tendency toward increasing the overall length of automobiles has led to the practice of setting the radiator grille a

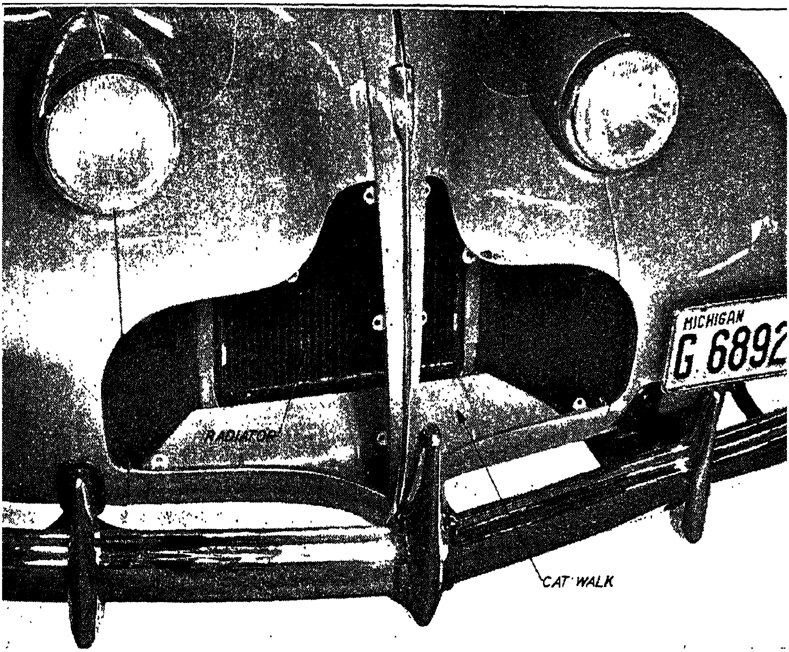


Fig. 1. 1939 Buick "Catwalk" Cooling (Radiator Grille Removed)
Courtesy of Buick Motor Division, G.M.S.C.

considerable distance ahead of the radiator. In order to accommodate the automobile hood, incorporating this greater overall length, to better visibility, it has been desirable to lower the hood line and also to narrow it, so as to permit the driver to have better vision to the roadway in order to make for safer driving. These features have combined to tend to a lowering of the radiator grille. In the case of the Buick automobile illustrated in Fig. 1, an area much wider than the radiator itself has been cut away from the fenders and the front of the car. This area is quite low and is

designed in the form of a scoop so that air entering through the grille is scooped both upward and inward, with the result that the fan, in connection with this forced concentration of air, causes the usual amount of air to be drawn through the radiator for satisfactory cooling. In the case of the Buick, the name given this particular design is "Cat-Walk" cooling, which is the term used to describe the location of the radiator grille in the "cat-walk" section of the front end of the car.

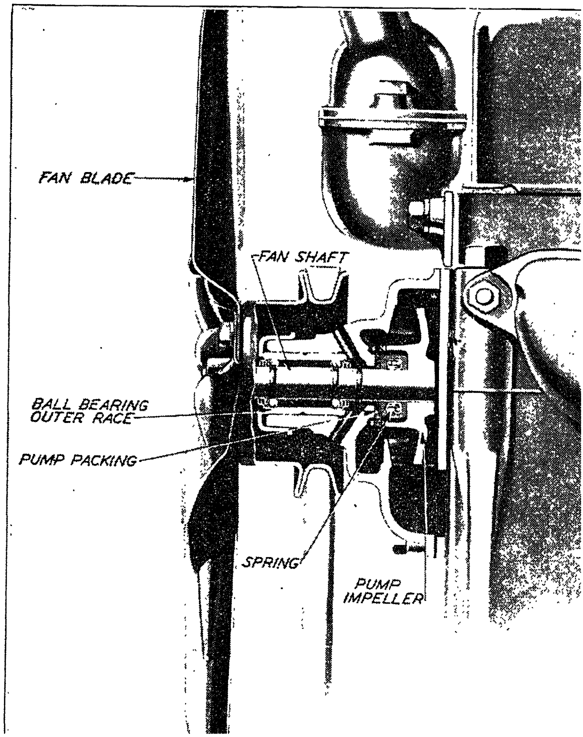


Fig. 2. 1939 Chevrolet Water Pump and Fan Shaft
Courtesy of Chevrolet Motor Division, G.M.S.C.

THE 1939 CHEVROLET FAN SHAFT AND WATER PUMP CONSTRUCTION

The fan shaft is mounted on double ball bearings which operate in an outer race, Fig. 2. The shaft is hardened and operates directly

on the bearing as an inner cone. These bearings are assembled, lubricated, and the lubricant protected by means of special retainers. No provision is made for lubrication during the life of the shaft. The fan is mounted on a flange pressed on to the outer end of the shaft while the impeller or the water pump is mounted on the inner end of the shaft. No provision is made for repacking the water pump. The packing provided is forced into contact with the inner flange of the pump housing by means of the special spring sealed within the packing; thus any wear is automatically compensated for.

MERCURY AND LINCOLN-ZEPHYR ELECTRIC TEMPERATURE GAUGE

The drawing, Fig. 3, shows this electric instrument in detail for both the engine unit and the instrument board unit. Each of

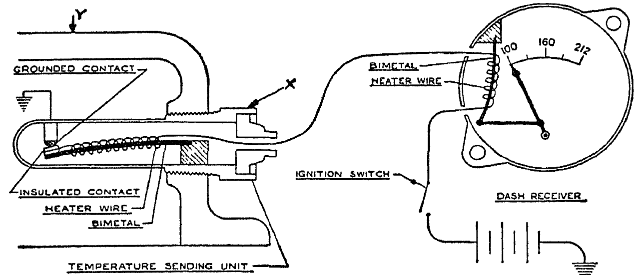


Fig. 3. Mercury, Lincoln-Zephyr Temperature Gage Operation with Low Temperature
Courtesy of Ford Motor Company

these units is provided with a bi-metal heat control and a bi-metal tongue, which is controlled by the heat of either the electrical circuit, or, in the case of the engine unit, by the heat from the water in the engine. The device is designed to operate so that the greater the amount of heat, the less the bending of the bi-metal unit in instrument board unit. The greater the amount of current flowing through the device, the lower the reading in temperature. Thus as the water heats up, the amount of current is cut down, until at the time it reaches 212° or boiling point the current is very low, so that the reading with the current entirely off is the same; that is, at 212°. This accounts for the fact that with the ignition off, the engine cold, the reading of the temperature gauge on the dash will be 212°. However, the instant the ignition is turned on, current

starts flowing through the device and the hand is retracted down as shown in Fig. 3. The engine unit shown on the left is Figs. 3 and 4 normally is grounded, so that the current passes through the engine unit to the ground. As this occurs, heat is generated in the engine unit coil, which will cause the bi-metal to bend, thus breaking the ground contact. As this happens, the current which has been heating up the bi-metal in the engine unit stops flowing, and, of course, the bi-metal cools and tends to return the contact points to contact again. This will allow more current to flow. This cycle of make and break is repeated over and over. The same amount of current

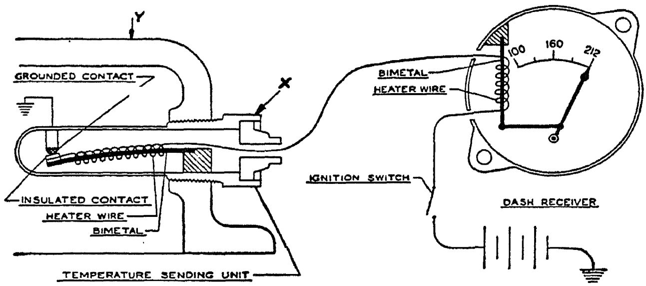


Fig. 4. Mercury, Lincoln-Zephyr Temperature Gage Operation with High Temperature
Courtesy of Ford Motor Company

is passing through both the engine and the dash unit since they are connected in series. The heating of the bi-metal in the temperature gauge on the right, Figs. 3 and 4, causes the pointer to be pulled over to the left, as shown in Fig. 3. The temperature sending unit which contains the engine bi-metal unit, is screwed into the water jacket *Y* and the inner end of this barrel is completely surrounded by the water within the engine jacket. It will be seen at once that the heat coming from the water surrounding the cylinder will also affect the bi-metal unit within the wall barrel *X*. This heat supplements the heat coming from the electric current flowing through. As the heat from the engine causes the engine bi-metal to bend farther and farther, less and less current flows, with the result that there is less heat in the temperature receiving gauge on the dash, so that this bi-metal tends to straighten, and as it resumes a perfectly straight position, the reading is brought up to 212°. If the engine bi-metal should be warm enough to break the contact so that no current was flowing, naturally the gauge bi-metal would

return to its straight position or no-current position, with the result that the reading would be the same as with the ignition turned off; that is, 212°.

1939 NASH WEATHER=EYE

This equipment, which is designed to maintain the car temperature at any desired point, as well as to condition the air by removing

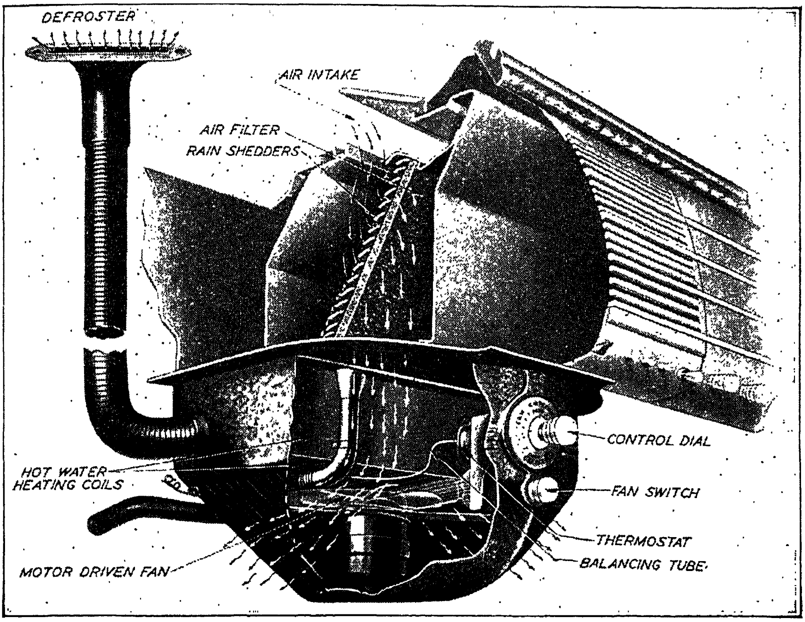


Fig. 5. 1939 Nash Weather-Eye
Courtesy of Nash-Kelvinator Corporation

moisture and soot or dirt, is housed under the instrument board within the cowl compartment, as shown in Fig. 5. It is designed to maintain desired conditions automatically, the car operator selecting the desired conditions, running from cold through medium to hot, by means of the Weather-eye car comfort control dial. After this has been set with the fan switch in On position, control is automatic. Air entering through the cowl ventilator first has any excess moisture removed from it by means of the "rain shedders." This excess moisture is drained off through a tube to the outside of the car. Dust, soot, and other foreign particles are removed from the fresh air by the filter. The motor-driven fan continues to pull the air

downward, passing it through the high efficiency hot water heating core from which point it is passed outward as indicated by the arrows flowing outward at either side of the unit, in sufficient amount to supply the entire car. The balancing tube, in conjunction with the thermostat, effects the automatic control.

The pressure built up by the fan is sufficient to overcome the normal air pressure from the outside of the car to a degree necessary to cause air to be passed from the car through door and window margins, so that there is a constant supply of fresh air entering through the cowl and being exhausted in this manner. Owing to the higher pressure within the car, there is no tendency for chilling drafts of air to enter, excepting through the cowl, where it is conditioned as just described before it contacts the occupants of the car. The defrosting equipment is illustrated, showing the left-hand of two similar tubes and nozzles supplied for this duty.

1939 STUDEBAKER CLIMATIZER

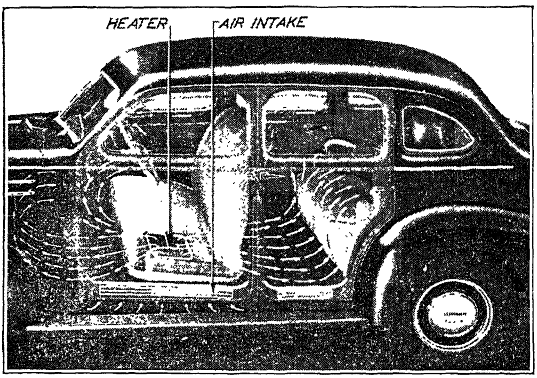


Fig. 6. Plan of Air Circulation of Studebaker Climatizer
Courtesy of The Studebaker Corporation

The Studebaker ten-point climatizer is supplied as special equipment on the 1939 cars and consists of a built-in system of air-conditioning and heating, as illustrated in Figs. 6 to 9, inclusive. In Fig. 7, it will be noted that the hot water radiator core is laid in a horizontal position, with the motor and fan mounted directly beneath it. Air is taken in through openings through and above the running board, also shown in Fig. 7. Before the incoming air

can be picked up by the fan, it is necessary for it to pass through the cylindrically shaped air filter which is mounted in a sealed metal

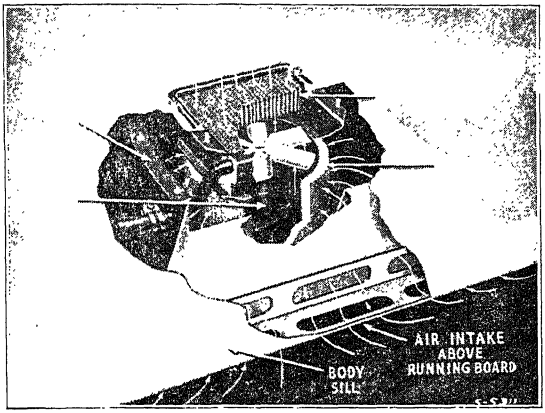


Fig. 7. Details of Construction and Operation of Studebaker Climatizer
Courtesy of The Studebaker Corporation

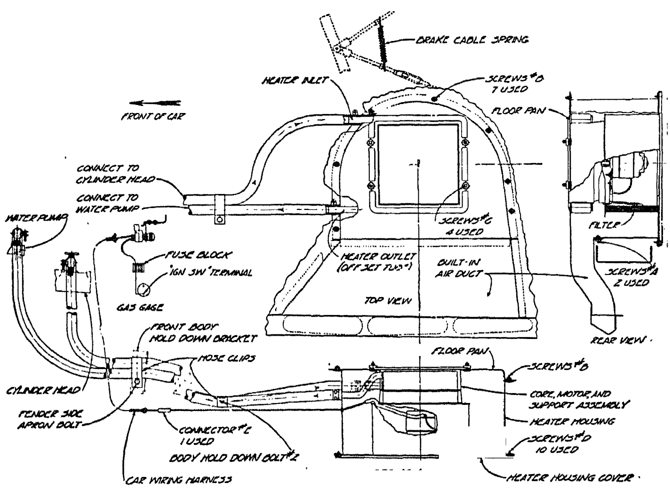


Fig. 8. Diagram Showing Installation of Studebaker's Ten-Point Climatizer
Courtesy of The Studebaker Corporation

housing. A metal duct for conducting the air to the heater is built into all Studebaker cars. The filtering element consists of a copper mesh with oil-impregnated air filter, designed to remove dust. The cleaned air passes through the radiator core, and from that point.

is distributed to the front and rear compartments of the car, as illustrated in Fig. 6, which shows the heater mounted under the front seat. The capacity of the heater is up to 250 cubic feet per minute. This is deemed sufficient to care for the normal needs of the occupants of the car in unusual circumstances such as dust storms or heavy rain storms where it would be desirable to have the windows closed, or practically so. With the windows practically closed, and this amount of air being drawn in, it naturally follows that the

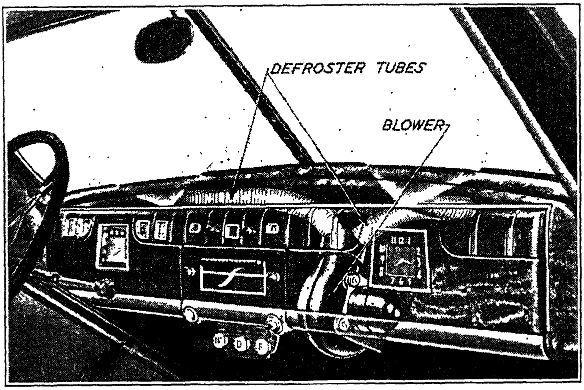


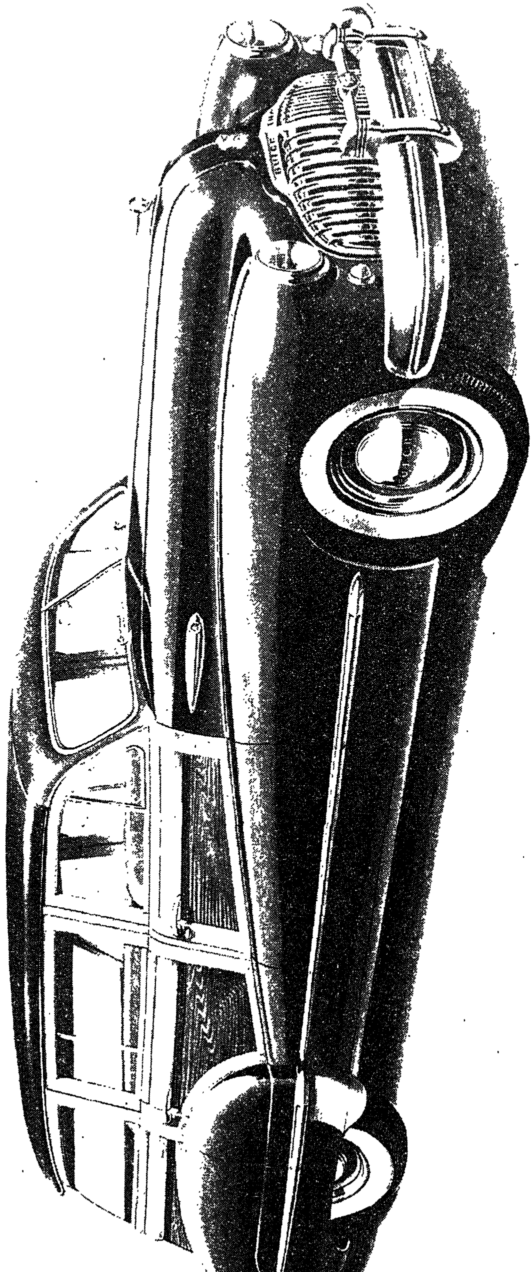
Fig. 9. Studebaker Defroster
Courtesy of The Studebaker Corporation

flow of air is out through the windows rather than in through them, even though they be left open a small amount. Thus it is found that rain will not enter, and the fog and frost which tend to collect on the car windows under such circumstances will be kept at a minimum. The details of the assembly of the ten-point climatizer are shown in Fig. 8, which shows a top, side and rear view.

For summer use of the climatizer, the water flow from the engine should be closed off by closing the valve on the top of the cylinder head. With the climatizer in use, no heating core is used for the windshield defroster, which is illustrated in Fig. 9. In this arrangement a special blower is used to pick up the heated air coming from the larger unit and force it through the flexible rubber manifold to the distributing point on the windshield.

Servicing the Climatizer. It is advisable to clean the filtering element from time to time, depending upon the amount of use and the nature of the country in which this use is obtained. For instance,

in a dusty area, it would be advisable to clean it more often than when the car is used in regions relatively free from dust. In order to service it, remove the bottom plate, which is attached to the heater housing by ten screws. Remove the two coil springs which are used to hold the filter in position on the heater core and motor support. Wash the filtering element with clean gasoline, after which it should be blown free of the gasoline to dry. After it is thoroughly dry, saturate the cleaning element with clean engine oil, allowing any excess to drain before reinstalling.



1941 CADILLAC RADIATOR SHUTTER CONTROL

This device consists of a thermostat, which is incorporated in the upper tank of the radiator, and a shutter control rod, which is linked to the radiator shutter in such manner as to allow the operation of the thermostat to open and close the radiator shutter. See Fig. 10. Two

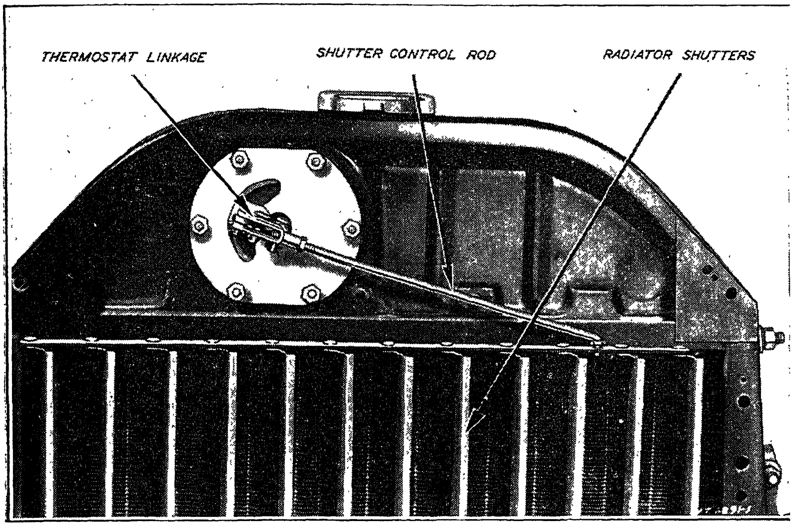


Fig. 10. Cadillac Thermostatic Radiator Shutter Control
Courtesy of Cadillac Motor Division, G. M. S. C.

thermostats are available, one known as the standard, which starts to open at 155° and is fully open at 175°, and a high reading thermostat which starts to open at 175°, and is fully open at 190°. The volatile anti-freezes should never be used with the high reading thermostat, as its point of opening is above their boiling point.

Thermostats may be checked for operation by removing them and placing them on a brick lying in a pan of water which is being heated. A thermometer in the water is used to check the temperature at which the thermostat operates. A 20-pound weight is placed on the end of the thermostat. The standard thermostat stem should raise 9/16 of an inch at 175° F. and bear the 20-pound weight at 190° F. The high reading thermostat should open 9/16 inch at 190° F. and bear the weight at 205° F.

POWER-OPERATED WINDOW REGULATORS

Where power-operated window regulators are installed, as in the case of certain of the deluxe automobiles, fluid pressure is utilized, this being provided by a centrally located pump, driven by a reversible motor securing its power from the power battery. When it is desired to raise a window, the switch is held in the *Up* position. The double acting switch is held in the *Down* position to lower the windows. In the *Up* position the switch causes a solenoid valve to be operated, and this directs the fluid flow to the window power cylinder

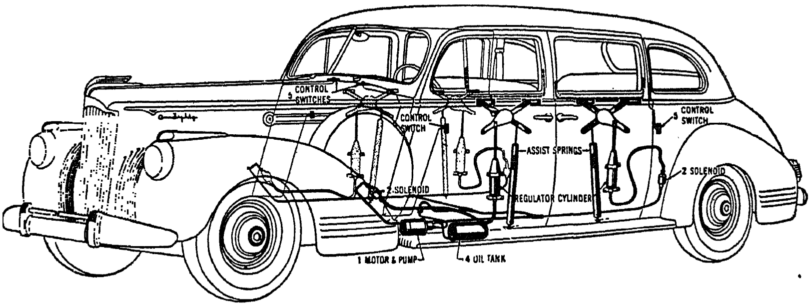


Fig. 11. 1941 Packard Sedan Fitted with Power-Operated Windows
Courtesy of the Packard Motor Car Company

corresponding to the control switch being operated. This operates the motor relay, which starts the pump in action, and the window power cylinder, which is directly connected to the window operating mechanism, causes the window pane to rise to the closed position, where it is held by the fluid pumped into the power cylinder. When the switch is thrown into the *Down* position, the motor relay is operated by the solenoid valve and the pump is driven in a reverse direction, with the result that fluid is withdrawn from the cylinder, and the window is lowered to the vacuum formed beneath the pistons, which vacuum is assisted by a tension spring. In case two switches are operated simultaneously, both windows are lowered because the relay switch on the electric motor will prevent current from flowing to both the forward and reverse coils at the same time. Such an installation is shown in Fig. 11.

MANIFOLD CONSTRUCTION

An engine is equipped with a number of external fittings more or less in the form of pipes or hollow passages which are termed manifolds. These are the intake gas and exhaust gas manifolds, Fig. 1. Those portions of the intake and exhaust manifolds which

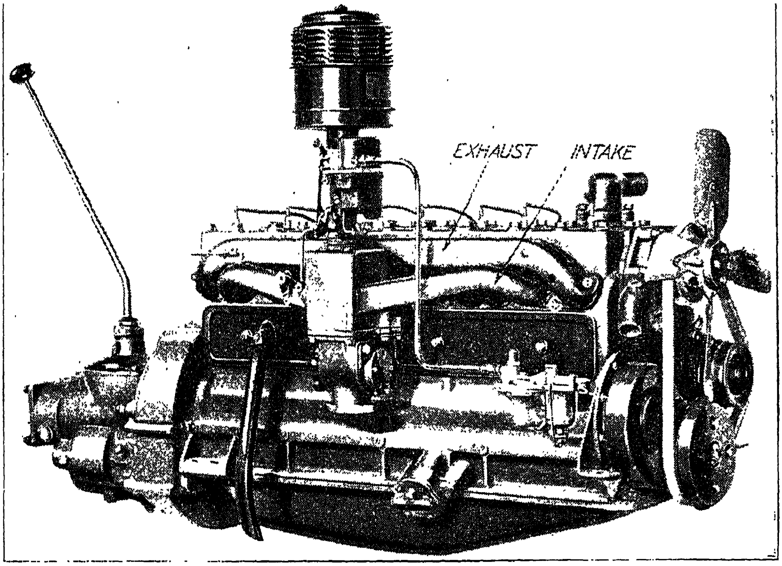


Fig. 1. Pontiac Engine Manifold System, Showing Intake and Exhaust

are found within the cylinder block or cylinder head are called ports. The manifold itself is the unit which is bolted to the block or cylinder head.

The purpose served by the manifold is well illustrated in Fig. 2, which is a cross section of an engine, showing the carburetor, intake manifold, valve, piston, and cylinder arrangements. A further study will show that the intake manifold is surrounded by other jackets. The intake manifold *AA* connects up to the port *B*, in which the intake valve is located. A damper *D* is shown in the upper portion of the exhaust manifold.

When this damper is closed, the exhaust is forced out into the lower sections C of the exhaust manifold.

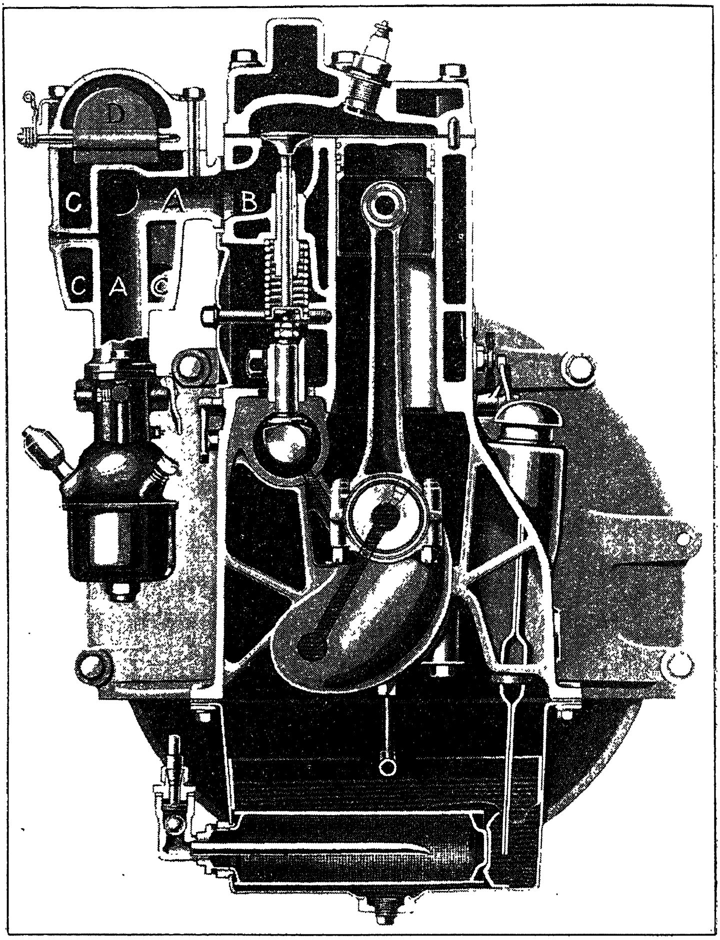


Fig. 2. Cross Section of Manifolds, Ports and One Cylinder of a Typical Vertical Automobile Engine

Most of the principles which are involved in manifold construction are shown in this figure. The combination of the two manifolds—intake and exhaust—is usually considered a desirable feature. It is very difficult to vaporize the heavy ends of the gasoline

so widely distributed for motorists. This accounts for the combination of the two manifolds, together with the hot spots and similar features.

Intake Manifolds. The design of the manifold has a great deal to do with the efficient operation of the internal-combustion engine. For smooth and even running, the charges taken into the cylinder should be of the same strength and quality. In other words, the charge taken into one cylinder should not be richer or in a better state of vaporization than the charge taken into another cylinder.

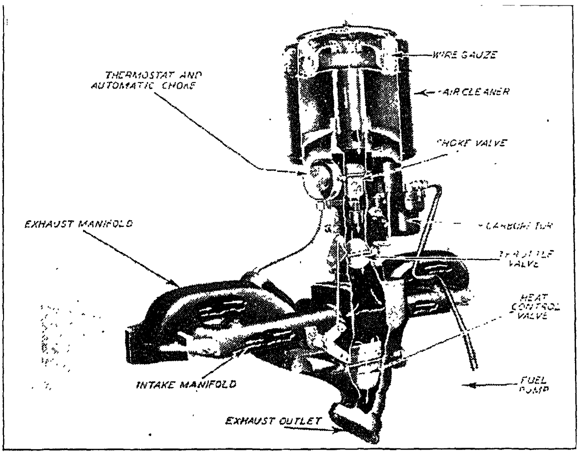


Fig. 3. Oldsmobile Fuel System Showing Intake and Exhaust Manifolds
The cutaway with arrows shows the path of fuel into engine through the intake manifold and out through the exhaust manifold.
Courtesy of Olds Motor Works

The distribution of the fuel to the cylinder should, therefore, be as even as possible, which depends greatly on the design of the intake manifold. The ideal form of charge is one that consists of dry gas, but the present-day fuel prevents such a charge unless the mixture is subjected to a high temperature. If the charge is too highly heated, the volumetric efficiency is destroyed and the power output of the engine drops off. A compromise between these two mixtures is used and the charge is introduced into the cylinder in the form of a gas fog. Even this has its disadvantages as some of the fuel will be deposited on the walls of the cylinder and manifold. The

manifold should, therefore, be designed so that wall condensation is reduced as much as possible. If condensation does occur, each cylinder will then receive its equal share of the wet mixture which is taken up by the incoming charge.

Four-Cylinder Intake Manifolds. The firing order and the valve timing also have something to do with the design of the manifold. When two cylinders in the same block next to each other fire one after the other and the intake valve opens a little before the previous intake valve closes, there is a possibility of

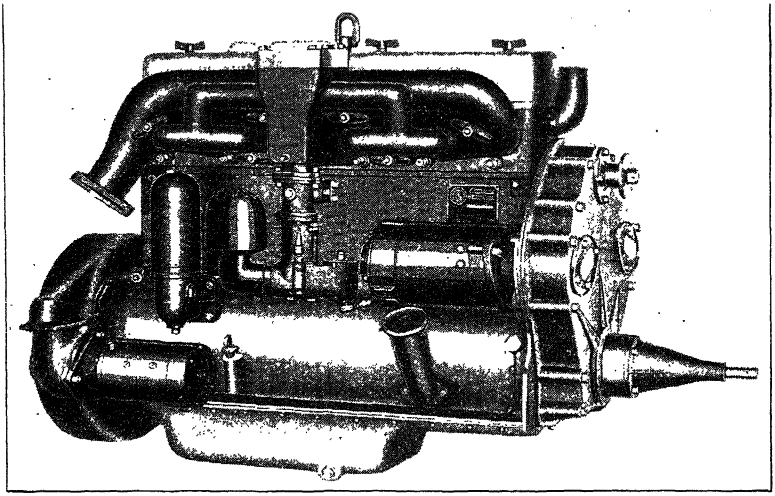


Fig. 4. Manifold and Carburetor System of the Continental Six-Cylinder Overhead Bus Engine

a supply of gas to the first cylinder being cut off by the suction of the second cylinder. See Figs. 3 and 4.

The inside of the intake manifold should be smooth and the passages should be large enough so that there is no obstruction to the flow of gases. The bends in the manifold should be so designed that the movement of the gases will prevent any fuel accumulating on the walls of the manifold through condensation. The flat-bottom manifold is well adapted for heat application and quick vaporization of condensed fuel moisture on its walls, as the drops of moisture fall to the floor at once. This applies to all manifolds whether for four, six, or more cylinders.

Six-Cylinder Intake Manifolds. The design of a manifold for a six-cylinder engine is governed by the firing order of the engine and, of course, that is governed by the placing of the cranks. In most six-cylinder engines the intake valves and ports are so laid out that two intake valves draw their charge for the same manifold connection. The most desirable arrangement for the six-cylinder engine is to have the suction in the intake manifold come from opposite ends of the engine. This prevents any one branch accumulating more moisture than another. There are two firing orders which allow this and they are the orders in use at the present time—1-5-3-6-2-4 and 1-4-2-6-3-5.

In most manifolds the bends have been made with radii, because it was thought that abrupt turns prevented the easy flow of the gas mixture. A later design of manifold that has proved successful is one of square cross-section. See Fig. 5. This manifold has the flat floor and all gas passages are exactly alike in shape. It is claimed that the abrupt turns tend to keep the particles of gasoline in the stream flow of the gases and direct them in a straight line. The turbulence set up by the abrupt turns helps to keep the particles in suspension at all times. Any particles of gasoline that may accumulate on the roof of the manifold and drop down must fall into the gas stream, while the square section gives the greatest floor area for the evaporation of the condensed fuel that might accumulate there.

Intake Manifolds for Eight-in-Line Engines. Two types of carburetors are used in connection with the eight-in-line engine. These are the single barrel and the double barrel or the single and the duplex carburetor. When the duplex carburetor is used, the manifolds are so arranged that four cylinders are fed from each side of the carburetor. This means a better distribution of gas. For instance, the cylinders 1-2-7-8 are fed from one side of the carburetor or barrel and cylinders 3-4-5-6 are fed from the other side of the carburetor or barrel with the result that more even distribution of gas is secured.

Fig. 5 illustrates the Studebaker intake manifold design which is used in connection with the Studebaker eight-cylinder engines which are fitted with the duplex carburetor. It will be noted that there are four horns running to the engine. Each one of these is

designed to care for two cylinders. It will further be noted that the manifold is wider at the center, in fact it has two distinct passages at the center. A short section of the manifold feeds cylinders 3-4-5-6 and the longer section of the manifold feeds cylinders 1-2-7-8.

The down-draft principle of manifold design represents certain engineering advance. While serving to bring the carburetor higher and thus shorten the lift required for the gasoline, in the carburetor, it serves to help in securing an equalization of the distribution of

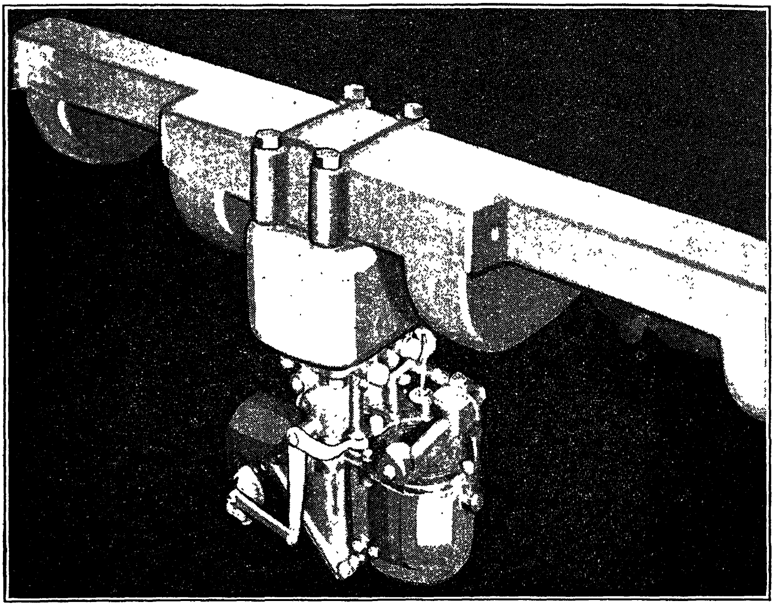


Fig. 5. Studebaker "Straight Eight" Intake Manifold with Duplex Carburetor

any globules of gasoline which may condense within the manifold. It will be seen at once that the gasoline which condenses in this type of manifold is certain to find its way into the engine rather than flow back into the carburetor, that is, this happens if the condensation occurs after the sloping portion of the manifold has been reached. Any condensation which occurs before this point is reached will find its way back into the carburetor where it will either be returned to the carburetor bowl or revaporized, depending of course upon the design of the carburetor.

Hot-Spot Manifolds. It is very desirable to place the carburetor close to the cylinders so that there will not be a great deal of condensation in the lower part of the intake manifold. In a system where a long riser pipe was used, a great deal of the condensed gasoline would drain back into the carburetor and cause loading and a means had to be devised to vaporize this fuel. The

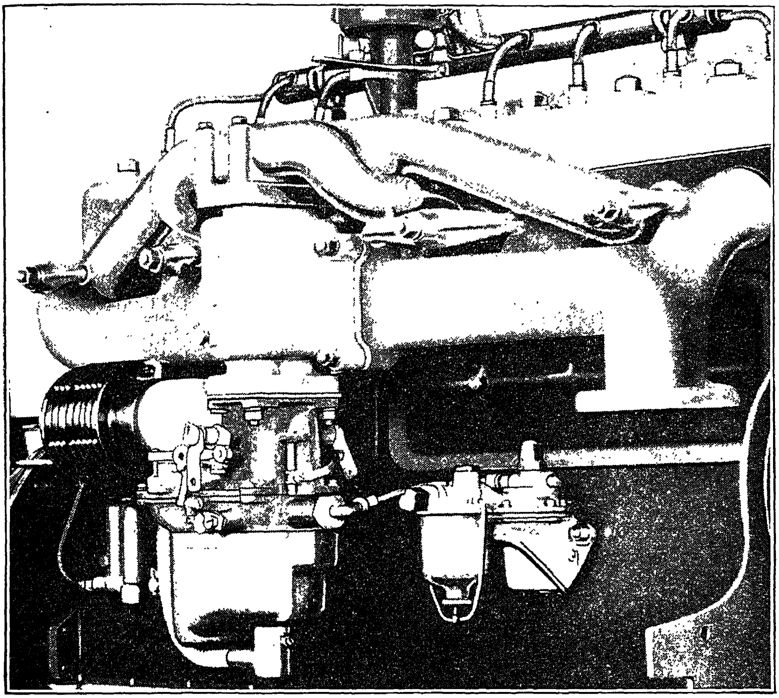


Fig. 6. Down-Draft Manifold for Duplex Carburetor and Eight-in-line Engine

hot-spot manifold was the outcome, Fig. 6. It is so constructed that a portion of it, consisting of solid metal, is in constant contact with the exhaust manifold so that in continuous running this solid metal in the intake manifold becomes heated, perhaps to a high degree. Furthermore, this "hot spot" is so located in the inlet passages that all fuel must pass over it before passing to the cylinders, with the result that any unvaporized particles remaining in the fuel gas are thrown against this highly heated spot and vaporized

instead of being carried into the cylinders as liquid particles, as would be the case without this heated spot.

An example of the application of the so-called "hot spot" is illustrated in the Oldsmobile manifold construction shown in Fig. 3. The intake manifold passes through the central section of the exhaust manifold with the result that much of the heat needed to vaporize the heavy ends of the raw gasoline is picked up by the fins cast on the outside of the intake manifold and given off to the incoming fuel charge. This results in better and more complete vaporization and in the drying out of the fuel charge.

Importance of Handling Exhaust Gases Properly. The design of the exhaust pipe should be such that it excludes any chance of

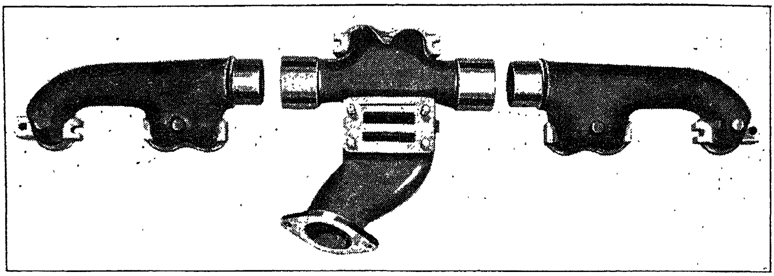


Fig. 7. Buick Three-Piece Exhaust Manifold

back pressure. It must be remembered that in multiple-cylinder engines, the strokes overlap. Consequently, at certain parts of the cycle there are two cylinders exhausting at the same time and the exhaust pipe should be large enough to take care of both. The exhaust pipe should gradually increase in size toward its outlet so that there will be no restriction. When a curved exhaust pipe is used, care should be taken in the layout of the curves so that a cylinder that is exhausting at high pressure does not blow over into a cylinder in which the pressure is low and in which the exhaust valve is open.

Muffler. The purpose of the muffler is to reduce the pressure of the gases by expansion to a point where they will emerge into the atmosphere without noise. This is generally done by providing a number of concentric chambers. The gas is allowed to expand from the first passage into the much larger second one, then into

the still larger third one, and so on, to the final and largest passage, which is connected to the pipe leading out into the atmosphere. This is not as simple as it sounds, for, if it is not well and wisely done, there will be back pressure which will reduce the power and speed of the engine, cause heating troubles, and may possibly cause the motor to stop.

Buick Exhaust Manifold. Fig. 7 illustrates the three-piece exhaust manifold used by Buick automobiles. The center section is used to carry the exhaust manifold valve which controls the amount of heat furnished to the carburetor riser, this being supplied through the slots appearing on the face of the manifold. The

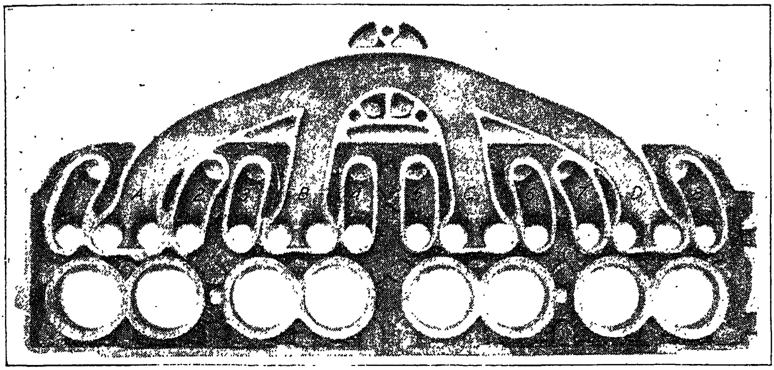


Fig. 8. Hudson Radial Intake Manifold

two end sections are fitted to the center section by means of a slip joint. This arrangement is provided in order to care for the normal expansion and contraction of a long engine block under temperatures encountered in normal usage. The end sections slip within the joint on the center section. In case old parts are being replaced with new and it is necessary to fit several of these together, the joint should be lapped by means of fine grinding compound. It should not be filed. When reassembling the joints they should be lubricated with a thick paste made of flake graphite and just enough engine oil to make the graphite stick to the two halves of the joint. The joint between the heat valve cover and the center section is secured by means of graphite and in case the joint is ever broken for repairs of any kind graphite should be used when it is being reassembled.

Hudson Radial Intake Manifold. Fig. 8 illustrates a sectioned view of the Hudson manifolding system. Both the intake and exhaust passages have been cut away to illustrate them. The intake passages are lettered *A, B, C,* and *D,* each one of these passages supplying fuel charges to the two valve ports connected therewith. The exhaust passages are numbered 1, 2, 3, 4, 5, 6, 7, and 8, each of these passages being connected to one of the exhaust valves. This

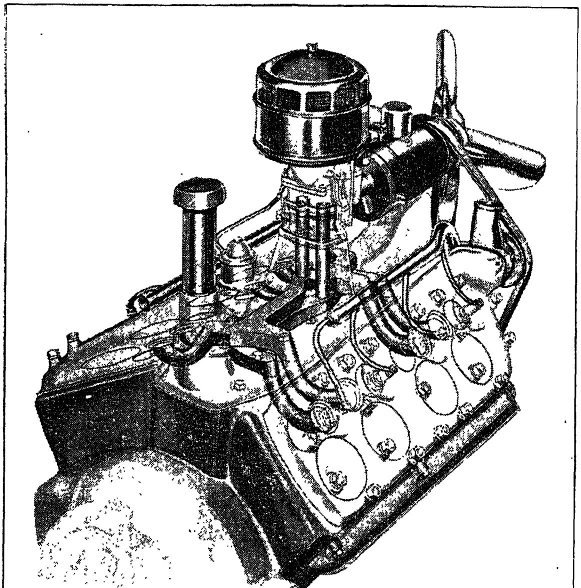


Fig. 9. Ford "V-8" Intake Manifold System

cutaway view shows sections of the cylinders. As a matter of fact the cylinder block has the intake and exhaust passages cast partially within it, other parts of the manifolding system being bolted to the block.

The advantage of this type of construction lies within the fact that incoming fuel charges are heated to an even temperature inasmuch as the intake passages are surrounded by the cooling solution contained within the engine block, as are also the exhaust

passages, so that an even temperature is maintained throughout the system.

Ford "V-8" Intake Manifold. The intake manifolding system of the Ford "V-8" as well as the down-draft carburetor features are illustrated in Fig. 9. It will be noted here that the two barrels of the down-draft carburetor are connected with the riser tubes

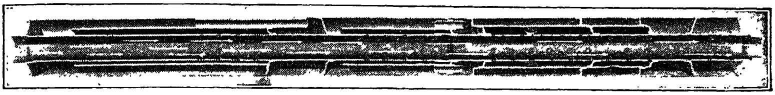


Fig. 10. Buick Resonance Muffler

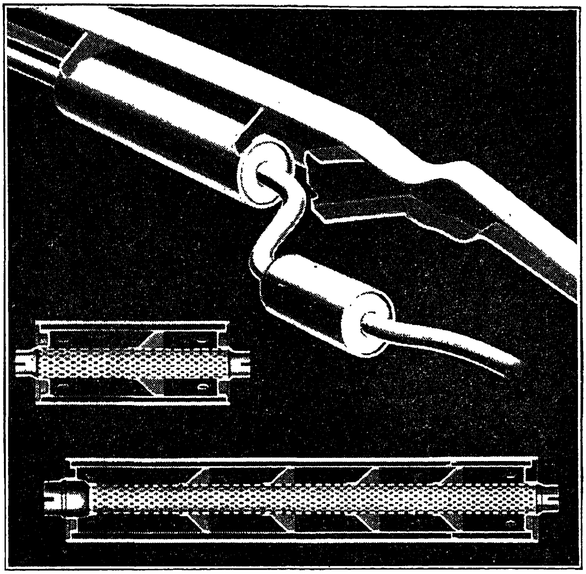


Fig. 11. Nash Exhaust Muffler System

and that each one of these tubes in turn is connected with a system of manifolds cast within the aluminum manifold header. If the student will follow out the path of one of these tubes from the carburetor to the manifold and then from it to the four cylinders fed by that barrel of the carburetor, he will see that the distance to each cylinder is approximately the same, also that there is no connection between the two tubes. This aids in giving each cylinder an equal fuel mixture and assures much more even operation than

where the eight cylinders are fed from one intake manifold. This arrangement also results in a considerable increase in power.

Exhaust from the engine is conducted through passages cast in the cylinder block to the exhaust manifolds which are bolted to the outer edges of the two cylinder blocks. These passages are not shown in the phantom view, Fig. 9.

Buick Resonance Muffler. The Buick muffler, Fig. 10, is a straight-through resonance type, consisting of a central tube open for the full length of the muffler, and having openings into resonance chambers. The resonance chambers function in the same manner as those used in the intake silencer and air cleaner. This type of construction results in greatly reduced back pressure and as the exhaust gases are not appreciably cooled in the muffler the corrosion from condensation and burning of the tubes is reduced to a minimum.

Dual Mufflers. Fig. 11 illustrates the Nash dual muffler connected to the car frame above and in sectioned view below. It will be noted that these mufflers are of the straight-through type, being provided with a central tube perforated with many openings into the outside chamber. The expansion of exhaust gases through these openings into the outer chamber results in their coming in contact with the outer wall which is constructed of several thicknesses of sheet metal with asbestos between. Practically all exhaust noises are eliminated by using two of these mufflers and allowing the gases from the larger one to flow through a tail pipe into the smaller one, and from it through a tail pipe into the open atmosphere.

Muffler Troubles. When the engine mysteriously loses power, it is well to look at the muffler. A dirty muffler filled up with oil and carbon, which results from the use of too much oil in the motor, will choke up the passages so that considerable back pressure is created. When this is suspected, tap the muffler all over lightly with a wooden mallet, and the exhaust gases will blow the sooty accumulations out.

On six-cylinder motors, and particularly motors with more than six cylinders, the sound of the exhaust is not an accurate guide to the firing of the cylinders, except for the expert mechanic with unusually keen hearing.

Muffler Abuse. The abuse of the muffler is dangerous to the muffler, to the car, and to the public. Fig. 12 illustrates a muffler

which was "shot" once too often. In this case no damage other than that to the muffler occurred. The practice of running an engine and then turning off the ignition to allow the muffler to "load" and then turn on the ignition and "shoot" is to be discouraged by all first-class mechanics. It may result in the loss of life. Instances are on record where mufflers have been blown for many yards with disastrous results.

Buick-Delco-Remy 1937 Manifold Heat Control. The intake manifold of the Buick is of the twin type integrally cast. The outside branch is used to supply cylinders numbers 1, 2, 7, and 8, and the inside branch supplies cylinders numbers 3, 4, 5, and 6. A heat

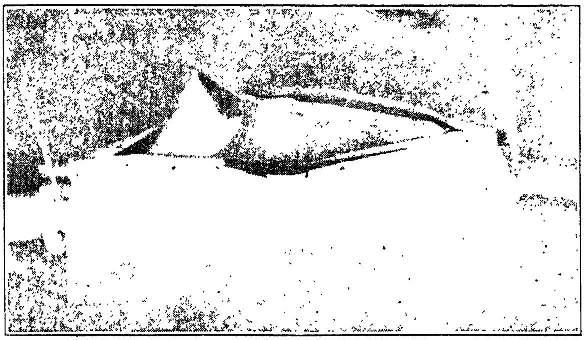


Fig. 12. A Muffler Which Was "Shot"

jacket is cast around the center section and is connected with the exhaust system.

The intake manifold of the Series 60-80-90 cars is provided with a drain directly below the barrels of the carburetor. This drain prevents any excessive raw fuel from the carburetor flowing into the branches of the intake manifold, and passing onto the cylinders to cause trouble. During the cranking operation, fuel at the bottom of the manifold is atomized by means of the stream of air from the outside of the manifold being drawn through the drain. The passage through which the air passes during the cranking is provided with a check valve which is closed by vacuum as soon as the engine starts operating. This will remain closed as long as the engine operates under its own power. When the engine stops, as in cranking, this

drain, shown in Fig. 13, operates to prevent flooding of the engine with raw fuel.

Intake Manifold Vacuum Gauge. If it is desired to check the vacuum within the intake manifold, a vacuum gauge should be used. Reading should be taken with the engine idled at a speed of approximately 8 miles per hour. It will be found that engines

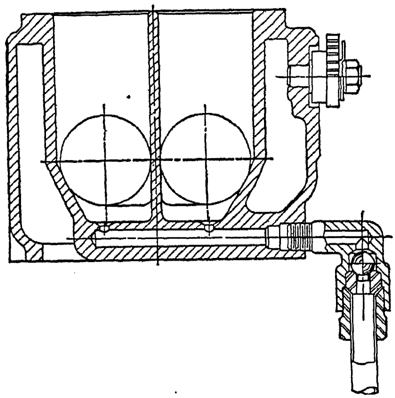


Fig. 13. Buick Intake Manifold Drain
Series 60-80-90

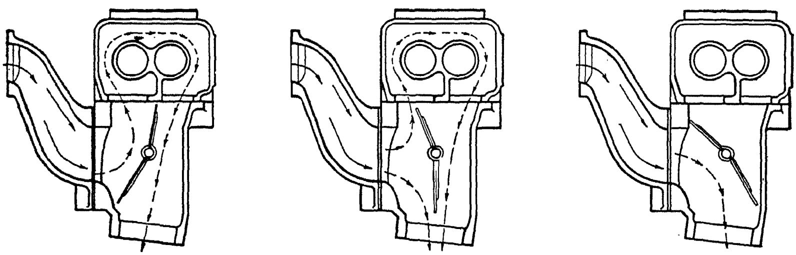


Fig. 14. Buick Heat Control Valve Operation

in good condition will draw a vacuum of from 18 to 20 inches mercury in low altitude sections of the country. On a properly tuned engine, the vacuum indicator needle should be steady. If the needle fluctuates and will not hold a steady reading, it indicates improper functioning of the engine. For complete information on using the vacuum gauge in testing to determine engine fault, the reader is referred to the Motor Analyzing Section in Volume Six.

Operation of the Buick Heat Control. The Buick intake manifold feed control system utilizes the exhaust gases of the engine to insure complete vaporization with a minimum consumption of fuel. This result is accomplished by surrounding the center portion of the intake manifold with a heat jacket, Fig. 14. which is connected to the exhaust system. As the hot gases pass from the exhaust manifold into the heat controlled valve body, they strike the heat controlled valve and are lifted upward into the heat jacket around the intake manifold. The gases next pass out of the heat jacket

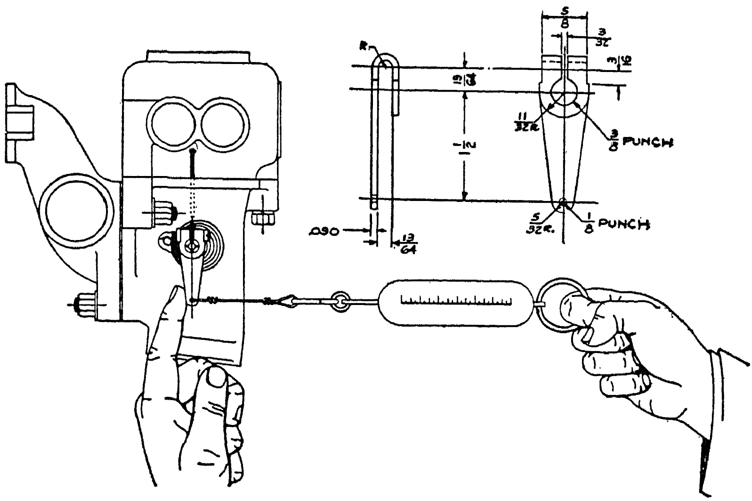


Fig. 15. Checking 1937 Buick Heat Control Thermostat
Courtesy of Buick Motor Company

back into the heat valve body, but on the opposite side of the heat controlled valve. Thus, the heat controlled valve acts both as a valve and as a partition. The amount of heat delivered to the heat jacket is automatically controlled by means of a thermostat which governs the quantity of exhaust gases and, consequently, the amount of heat by determining the position of the heat controlled valve. As shown in Fig. 14, the greatest amount of heat is available when the valve is in the "heat-on" position. The amount of heat decreases to the "heat-medium" position and the "heat-off" position. The heat control valve is so designed that when the engine is operated under

wide open throttle conditions the force of exhaust gas causes valve to be held open, since one side of the valve is longer than the other.

The thermostat is shown in Fig. 15. It controls the heat of the control valve automatically. Setting of the thermostat should be approximately ¼ turn wind-up at normal room temperature, causing tension to be applied to the damper valve, holding it in the heat-on position and forcing the exhaust gases through the heat jacket. Heat conducted by the damper valve shaft of the thermostat causes it to unwind, reducing tension on the damper valve which allows the valve to be forced by the exhaust pressure toward the off position. The thermostat is also affected by the temperature of the air blast from the fan. Thus, we find that the heat control varies with outside air temperature, as well as directly from exhaust heat. The thermostat proper is made of two strips of metal of unequal expansion characteristics. These two metals being fastened together as one strip. When heat is applied to this bi-metal, it has the effect of causing the thermostat coil to wind or unwind. This serves to actuate the valve shaft and controls the amount of heat.

Thermostat Tension. If it is found desirable to check the tension on the thermostat, this operation should be carried out as indicated below. The first step is to have the whole manifold assembly at room temperature (approximately 70 degrees). Next, attach a spring balance to the lever and note the pull the instant the lever begins to move. This movement may be determined by holding the finger lightly against the back of the lever as shown in Fig. 15. In the case of the 40 Series Buick, the pull should be 3½ to 4½ ounces and in the cases of the 60-80-90 Series Buicks, the pull should be 8 to 9½ ounces. Before making this test, make certain that all moving heat controlled parts operate freely, but in no case should oil be used on these parts.

Heat Valve Position Adjustment. When the engine is cold, the heat valve is held in the closed position by the tension of the thermostat spring. This closed position is indicated by the approximate vertical position of the counterweight lever. A spring acts as an anti-rattle device and resists the tendency of the thermostat spring to throw the weight lever completely up to the vertical position where the valve would contact the housing. If adjustment is necessary, it is made by bending the regulating clamp.

9219

GLOSSARY

THE following glossary of automobile terms is not intended in any sense as a dictionary and only words used in the articles themselves have been defined. The definitions have been made as simple as possible, but if other terms unfamiliar to the reader are used, these should be looked up in order to obtain the complete definition.

A. A. A.: Abbreviation for American Automobile Association.

Abrasive: Any hard substance used for grinding or wearing away other substances.

Absorber, Shock: See "Shock Absorber".

Accelerate: To increase the speed.

Acceleration: The rate of change of velocity of a moving body. In automobiles, the ability of the car to increase in speed. Pickup.

Accelerator: Device for rapid control of the speed for quick opening and closing of the throttle. Usually in the form of a pedal, spring returned, the minimum throttle opening being controlled by the setting of the hand throttle.

Accessory: A subordinate machine that accompanies or aids a more important machine; as, a horn is an accessory of an automobile.

Accumulator: A secondary battery or storage battery. It usually consists of chemically prepared lead plates combined with an acid solution. Upon being charged with an electric current from a primary source, a chemical change takes place which enables the plates in their turn to give a current of electricity when used as a source of power, the plates at the same time returning to their original chemical state.

Acetone: A liquid obtained as a by-product in the distillation of wood alcohol, and used in connection with reservoirs for storing acetylene for automobile lights, as it dissolves many times its own volume of acetylene gas.

Acetylated Alcohol: Alcohol which has been denatured by the addition of acetylene, which also increases its fuel value. See "Alcohol, Denatured".

Acetylene: A gaseous hydrocarbide used as an illuminant; is usually generated for that purpose by the action of water on calcium carbide.

Acetylene Generator. A closed vessel in which acetylene gas may be produced by the action of water on calcium carbide and which supplies the gas under uniform pressure.

Acetylene Lamp: A lamp which burns acetylene gas.

Acetylite: Calcium carbide which has been treated with glucose. It is used to obtain a more uniform and slower production of acetylene gas than can be obtained with the untreated calcium carbide.

Acid: In connection with automobiles the term usually means the liquid or electrolyte used in the storage battery. See "Electrolyte".

Acid Cure. Method of rapid vulcanization of rubber without heat. Used in tire repairs. The agent is sulphur chloride.

Acidimeter. An instrument for determining the purity of an acid.

Active Material: Composition in grids that forms plates of a storage battery. It is this material in which the chemical changes occur in charging and discharging.

Adapter: Device by which one type of lamp burner may be used instead of the one for which the lamp was designed. Usually a fitting by which a gas or oil lamp may be converted into an electric lamp.

Adhesion: That property of surfaces in contact by virtue of which one of them tends to stick to the other. It is used as synonymous with friction. The adhesion of wheels acts to prevent slipping.

Adjustment: The slackening or tightening up of parts to compensate for wear, reduce friction, or secure better contact.

Admission: In a steam engine, the letting in of the steam to the cylinder; in gas engine, the letting in of mixture of gas and air to the cylinder.

Advanced Ignition: Usually called *advancing the spark*. Setting the spark of an internal-combustion motor so that it will ignite the charge at an earlier part of the stroke.

Advance Sparking: A method by which the time of occurrence of the ignition spark may be regulated, by completing the electric circuit at the earlier period.

Advancing the Spark: See "Advanced Ignition".

Aerodynamics: The science of atmospheric laws, i.e., the effects produced by air in motion.

After-Burning: Continued burning of the charge in an internal-combustion engine after the explosion.

After-Firing: An explosion in the muffler or exhaust passages.

A-h: Abbreviation for *ampere hour.*

Air Bottle: A portable container holding compressed air or carbon dioxide for tire inflation.

Air-Bound: See "Air Lock".

GLOSSARY

Air Compressor: A machine for supplying air under pressure for inflating tires, starting the motor, etc.

Air Cooled: Cooled by air direct. Usually referring to the cylinder of an engine, whose heat caused by the combustion within it is carried away by air convection and radiation.

Air Cooling: A system of dispersing by air convection the heat generated in the cylinder of an internal-combustion motor.

Air Intake: An opening in a carbureter to admit air.

Air Leak: Entrance of air into the mixture between carbureter and cylinder.

Air Lock: Stoppage of circulation in the water or gasoline system caused by a bubble of air lodging in the top of a bend in the pipe.

Air Pump: A pump operated by the engine or by hand to supply air pressure to the oil tank or gasoline tank; sometimes called *pressure pump.*

Air-Pump Governor: A device to regulate the speed of the air pump so as to give a uniform air pressure.

Air Resistance: The resistance encountered by a surface in motion. This resistance increases as the square of the speed, which makes it necessary to employ four times as much power in order to double a given speed.

Air Tube: See "Pneumatic Tire".

Airless Tire: Name of special make of non-puncturable resilient tire.

A. L. A. M.: Abbreviation for Association of Licensed Automobile Manufacturers, now out of existence.

A. L. A. M. Horsepower Rating: The horsepower rating of an automobile found by the standard horsepower formula approved by the Association of Licensed Automobile Manufacturers. Since the dismemberment of this organization, the formula is usually called the S.A.E. rating. This formula is h.p. = bore of cylinder (in inches) squared × No. of cylinders ÷ 2.5, at a piston speed of 1000 feet per minute.

Alarm, Low-Water: See "Low-Water Alarm".

Alcohol: A colorless, volatile, inflammable liquid which may be used as fuel for internal-combustion engines.

Alcohol, Denatured: Alcohol rendered unfit for drinking purposes by the addition of wood alcohol, acetylene, and other substances.

Alignment: The state of being exactly in line. Applied to crankshafts and transmission shafts and to the parallel conditions of the front and rear wheels on either side.

Alternating Current: Electric current which alternates in direction periodically.

Ammeter: An instrument to measure the values of current in an electric circuit directly in amperes. Also called *ampere meter*.

Amperage: The number of amperes, or current strength, in an electric circuit.

Ampere: The practical unit of rate of flow of electric current, measuring the current intensity.

Ampere Hour: A term used to denote the capacity of a storage battery or closed-circuit primary battery. A battery that will deliver three amperes for six hours is said to have an eighteen-ampere-hour capacity.

Ampere Meter: See "Ammeter".

Angle-Iron Underframe: An underframe constructed of steel bars whose cross section is a right angle.

Anneal: To make a metal soft by heating and cooling. To draw the temper of a metal.

Annular Gear: A toothed wheel upon which the teeth are formed on the inner circumference.

Annular Valve: A circular valve having a hole in the center.

Annunciator: An installation of electric signals or a speaking tube to allow the passengers in an enclosed car to communicate with the driver.

Anti-Freezing Solution: A solution to be used in the cooling system to prevent freezing in cold weather; any harmless solution whose freezing point is somewhat below that of water may be used.

Anti-Friction Metal: Various alloys of tin and lead used to line bearings, such as Babbitt metal, white metal, etc.

Anti-Skid Device: Any device which may be applied to the wheels of a motorcar to prevent their skidding, such as tire coverings with metal rivets in them, chains, etc.

Apron: Extensions of the fenders to prevent splashing by mud or road dirt.

Armature: In dynamo-electric machines, the portion of a generator in which the current is developed, or in a motor, the portion in which the current produces rotation. In most generators in automobile work, the armature is the rotating portion. In magnetic or electromagnetic machines the armature is the movable portion which is attached to the magnetic poles.

Armature Core: The iron portion of the armature which carries the windings and serves as part of the path for the magnetic flux.

Armature Shaft: The shaft upon and with which the armature rotates.

Armature Winding: Electrical conductors, usually copper, in an armature, and in which the current is generated, in case of a generator, or in which they produce rotation in a motor.

Artillery Wheel: A wheel having heavy wood spokes.

Aspirating Nozzle: An atomizing nozzle to make the liquid passing through it pass from it in the form of a spray.

Assembled Car: A car whose chief parts, such as engine, gearset axles, body, etc., are manufactured by different parts makers, only the final process of putting them together being carried out in the car-making plant.

Atmospheric Line: A line drawn on an indicator diagram at a point corresponding with the pressure of the atmosphere.

Atmospheric Valve: See "Suction Valve".

Atomizer: A device by which a liquid fuel, such as gasoline, is reduced to small particles or to a spray; usually incorporated in the carbureter.

Auto: (1) Popular abbreviation for automobile. (2) A Greek prefix meaning self.

GLOSSARY

Auto-Bus: An enclosed motor-driven public conveyance, seating six or more people; usually has a regular route of travel.

Autocar: A motorcar or automobile; a trade name for a particular make of automobile.

Auto-Cycle: See "Motorcycle".

Autodrome: A track especially prepared for automobile driving, particularly for races.

Autogenous Welding: See "Welding, Autogenous".

Auto-Igniter: A small magneto generator or dynamo for igniting gasoline engines, the armature of which is connected with the flywheel by gears or by friction wheels, so that electric current is supplied as long as the engine revolves.

Autoist: One who uses an automobile.

Automatic Carbureter: A vaporizer or carbureter for gasoline engines whose action is entirely automatic.

Automatic Cut-Out: See "Cut-Out, Automatic".

Automatic Spark Advance: Automatic variation of the instant of spark occurrence in the cylinder. Mechanical advancing and retarding of the spark to correspond with and controlled by variations in crankshaft speed.

Auto-Meter: Trade name for special make of combined speedometer and odometer.

Automobile: A motor-driven vehicle having four or more wheels. Some three-wheeled vehicles are properly automobiles, but are usually called *tricars*.

Automobilist: The driver or user of an automobile.

Auto Truck: A motor-driven vehicle for transporting heavy loads; a heavy commercial car.

Auxiliary Air Valve: Valve controlling the admission of air through the auxiliary air intake of a carbureter.

Auxiliary Air Intake: Opening through which additional air is admitted to the carbureter at high speeds.

Auxiliary Exhaust: Ports cut through cylinder walls to permit exhaust gases to be released from the cylinder when uncovered by the piston. These are sometimes used as an additional scavenging means for the regular exhaust valves.

Auxiliary Fuel Tank: See "Fuel Tank, Auxiliary".

Auxiliary Spark Gap: See "Spark Gap, Outside".

Axle: The spindle with which a wheel revolves or upon which it revolves.

Axle, Cambered: An axle whose ends are slanted downwards to camber the wheels.

Axle, Channel: An axle which is U-shaped in cross section.

Axle, Dead: Solid, fixed, stationary axle. An axle upon which the wheels revolve but which itself does not revolve.

Axle, Dropped: An axle in which the central portion is on a lower level than the ends.

Axle, Floating: A full-floating axle. A live axle in which the shafts support none of the car weight, but serve only to turn the wheels.

Axle, I-Beam: An axle whose cross section is in the shape of the letter I.

Axle, Live: An axle in which are comprised the driving shafts that carry the power of the motor to the driving wheels.

Axle, Semi-Floating: A live axle in which the driving shafts carry all of the car weight as well as transmitting the driving torque.

Axle, Three-Quarters Floating: A live axle in which the shafts carry a part of the weight of the car, while the housing carries the balance of the weight. It is intermediated by a floating axle and the semi-floating axle.

Axle, Trussed: An axle in which downward bending is prevented by a truss.

Axle, Tubular: An axle formed of steel tubing. Usually applied to the front axles, but sometimes used in referring to tubular shafts of rear axles.

Axle Casing: That part of a live axle that encloses the driving shafts and differential and driving gears. Axle housing.

Axle Housing: See "Axle Casing".

Axle Shaft: The member transmitting the driving torque from the differential to the rear wheels.

B

Babbitt: A soft metal alloy used for lining the bearings of shafts.

Back-Firing: An explosion of the mixture in the intake manifold or carbureter caused by the communication of the flame of explosion in the cylinders. Usually due to too weak a mixture. Popping.

Back Kick: The reversal of direction of the starting, caused by back-firing.

Backlash: The play between a screw and nut or between the teeth of a pair of gear wheels.

Back Pressure: Pressure of the exhaust gases due to improper design or operation of the exhaust system.

Baffle Plate: A plate used to prevent too free movement of a liquid in the container. In a gas engine cylinder, a plate covering the lower end of the cylinder to prevent too much oil being splashed into it. The plate has a slot through which the connecting rod may work.

Balance Gear: See "Differential Gear".

Balancing of Gasoline Engines: Insuring the equilibrium of moving parts to reduce the vibration and shocks.

Ball-and-Socket Joint: A joint in which a ball is placed within a socket recessed to fit it, permitting free motion in any direction within limits.

Ball Bearing: A bearing in which the rotating shaft or axle is carried upon a number of small steel balls which are free to turn in annular paths, called *races*.

Balladeur Train: A French name for a sliding change-speed gear.

Barking: The sound made by the explosions caused by after-firing.

Base Bearing: See "Main Bearing".

Base Explosion: See "Crankcase Explosion".

Battery: A combination of primary or secondary cells, as dry cells or storage cells.

Battery, Dry: See "Dry Battery".

Battery, Storage: See "Accumulator".

Battery Acid: The electrolyte in a storage battery.

GLOSSARY

Battery-Charging Plug: Power terminals to which the leads of a storage battery may be connected for charging the battery.

Battery Gage: (1) Voltmeter or ammeter or voltammeter for testing the specific gravity of the electrolyte in a secondary battery.

Battery Syringe: A syringe used to draw out a part of the electrolyte or solution from a storage battery cell to test its density and specific gravity.

Baume: A scale indicating the specific gravity or density of liquids and having degrees as units. Gasoline of a specific gravity of .735 has a gravity of 61 degrees

Bearing: A support of a shaft upon which it may rotate.

Bearing, Annular Ball: A ball bearing consisting of two concentric rings, between which are steel balls.

Bearing, Ball: A bearing in which the rotating shaft and the stationary portion of the bearings are separated from sliding contact by steel balls. A steel collar fitted to the shaft rolls upon the balls, which in turn roll upon steel collar attached to the stationary portion of the bearing.

Bearing, Cup and Cone: A ball bearing in which the balls roll in a race, which is formed between a cone-shaped fixed collar and a cup-shaped shaft collar.

Bearing, Main: The bearing in which rotates the crankshaft of an engine.

Bearing, Plain: A bearing in which the rotating shaft is in sliding contact with the bearing supporting it.

Bearing, Radial: A bearing designed to resist loads from a direction at right angles to the axis of the shaft.

Bearing, Roller: A bearing in which the journal rests upon, and is surrounded by, hardened steel rollers which revolve in a channel or race surrounding the shaft.

Bearing, Thrust: A bearing designed to resist loads or pressures parallel with the axis of the shaft.

Bearing Cap: That portion of a plain bearing detachable from the stationary portion, and which holds the bearing bushing and shaft.

Bearing Surface: The projected area of a bearing in a perpendicular plane to the direction of pressure.

Beau de Rochas Cycle: The four-stroke cycle used in most internal-combustion engines. This cycle was proposed by M. Beau de Rochas and put into practical form by Dr. Otto. See "Four-Cycle".

Belt and Clutch Dressing: A composition to be applied to belts and clutches to prevent them from slipping.

Belt Drive: A method of transmitting power from the engine to the countershaft or jack shaft by means of belts.

Benzine: A petroleum product having a specific gravity between that of kerosene and gasoline. Its specific gravity is between 60 degrees and 65 degrees Baumé.

Benzol: A product of the distillation of coal tar. Coal tar benzine. Used as a rubber solvent and in Europe as a motor fuel.

Berline Body: A limousine automobile body having more than two seats in the back part.

Bevel-Gear: Gears the faces of whose teeth are not parallel with the shaft, but are on a beveled edge of the gear wheel.

Bevel-Gear Drive: Method of driving one shaft from another at an angle to the first. The chief method of transmitting the drive from the propeller shaft to the rear axle shafts.

B. H. P.: An abbreviation for brake horsepower.

Bicycle: A two-wheeled vehicle propelled by the pedaling of the rider.

Binding Posts: See "Terminals".

Bleeder: A by-pass in the sight-feed of a mechanical oiling system by which the oil delivered through that feed is allowed to pass out instead of going to the bearings.

Blister: A defect in tires caused by the separation of the tread from the fabric.

Block Chain: A chain used in automobiles, bicycles, etc., of which each alternate link is a steel block.

Blow-Back: The backward rushing of the fuel gas through the inlet valve into the carbureter.

Blower Cooled: A gas engine cooled by positive circulation of air maintained by a blower.

Blow-Off: A blow-out caused by the edge of the bead of tire becoming free from the rim and allowing the tube to protrude through the space thus formed.

Blow-Out: The rupture of both the inner tube and outer casing of a pneumatic tire.

Blow-Out Patch: See "Patch, Tire Repair".

Body: (1) The superstructure of an automobile; the part that resembles and represents the body of a horse-drawn vehicle. (2) In oils, the degree of viscosity. The tendency of drops of oils to hang together.

Body Hangers: Attachments to or extensions of the frame for holding the body of the vehicle. They should be properly called frame hangers.

Boiler: A vessel in which water is evaporated into steam for the generation of power.

Boiler, Fire-Tube: A tubular steam boiler in which the end plates are connected by a number of open ended thin tubes, the spaces around which are filled with water, the hot gases passing through the tubes.

Boiler, Flash: A steam boiler in which steam is generated practically instantaneously. There is practically no water or steam stored in the boiler. A flash generator.

Boiler, Water-Tube: A steam boiler in which the water is carried in metal tubes, around which the hot gases circulate.

Boiler Alarm: See "Low-Water Alarm".

Boiler Covering: A non-conducting substance used as a covering for boilers to prevent loss of heat by radiation.

Boiler-Feed Pump: An automatic and self-regulating pump for supplying a boiler with feed water.

Boiler-Feed Regulator: A device to make the feed-water supply of the boiler automatic.

Bonnet: (1) The hood or metallic cover over the front end of an automobile. See "Hood". (2) The cover over a pump-valve box, or a slide-valve casing. (3) A cover to enclose and guide the tail end of a

steam-engine-valve spindle or the cover of a piston-valve casing. (4) The pan underneath the engine in an automobile.

Boot: A covering to protect joints from dirt and water or to prevent the leakage of grease. (2) Space provided for baggage at the rear of a car.

Bore: The inside diameter of the cylinder.

Boss: An enlarged portion of a part to give a point for attachment of another part.

Bottom: The meshing of gears without clearance.

Bow Separator: A part to prevent chafing of the bows of a top when folded.

Boyle's Law of Gases: A law defining the volume and pressure of gases at constantly maintained temperatures. It states that the volume of a gas varies inversely as the pressure so long as the temperature remains the same; or, the pressure of a gas is proportional to its density.

Brake: An apparatus for the absorption of power by friction, and by clamping some portion of the driving mechanism to retard or stop the forward motion of the car.

Brake, Air-Cooled: A brake whose parts are ridged to present a large surface for transferring to the air the frictional heat generated in them.

Brake, Band: A brake which contracts upon the outside of a drum attached to some part of the driving mechanism.

Brake, Constricting Band: A form of brake applied by tightening a band around a pulley or drum.

Brake, Differential: A brake acting upon the differential gear.

Brake, Double-Acting: A brake which will hold when the drum is rotating in either direction.

Brake, Drum, and Band: See "Brake, Band".

Brake, Emergency: A brake intended to be used in case the service brake does not act to a sufficient extent.

Brake, Expanding-Band: A drum brake in which the braking force is exerted by a band forced outward against the inner rim of a pulley.

Brake, External-Contracting: A brake consisting of a drum affixed to a rotating part, the outer surface of which is encircled by a contracting band.

Brake, Foot: A brake designed to be operated by the driver's foot. A pedal brake. Usually the service brake.

Brake, Front-Wheel: A brake designed to operate on the front wheels of the car.

Brake, Gearset: A brake designed to act on the transmission shaft and attached to the gearbox.

Brake, Hand: A brake designed to be operated by means of a hand lever. Usually the emergency brake.

Brake, Hub: A brake consisting of a drum secured to one of the wheels. This is the usual type.

Brake, Internal: A brake in which an expanding mechanism is contained within a rotating drum, the expansion bringing pressure to bear on the drum.

Brake, Internal-Expanding: A brake consisting of a drum, against the inside of which may be expanded a band or a shoe.

Brake, Motor: A brake in an electric vehicle which acts upon the armature shaft of the motor.

Brake, Service: A brake designed to be used in ordinary driving. It is usually operated by the driver's foot.

Brake, Shoe: A brake in which a metal shoe is clamped against a revolving wheel.

Brake, Transmission: A brake designed to act upon the transmission shaft.

Brake, Water-Cooled: A brake through which water may be circulated to carry off the frictional heat.

Brake Equalizer: A mechanism applied to a system of brakes operated in pairs to assure that each brake shall be applied with equal force.

Brake Horsepower: The horsepower supplied by an engine as shown by the application of a brake or absorption dynamometer.

Brake Housing: A casing enclosing the brake mechanism.

Brake Lever: The lever by which the brake is applied tc the wheel.

Brake Lining: The wearing surface of a brake; usually arranged to be easily replaced when worn.

Brake Pedal: Pedal by which the brake is applied.

Brake Pull Rod: A rod transmitting the tension from the lever or pedal to the movable portion of the brake proper.

Brake Ratchet: A device by which the brake lever or brake pedal can be set in position and retained there; usually consists of a notched quadrant with which a movable tongue on the lever head or pedal engages.

Brake Rod: The rod connecting the brake lever with the brake.

Brake Test: A test of a motor by means of a dynamometer to determine its power output at different speeds.

Braking Surface: The surface of contact between the rotating and stationary parts of a brake.

Braze: To join by brazing.

Brazing: The process of permanently joining metal parts by intense heat.

Breaker Strip: A strip of canvas placed between the tread and body of an outer tire casing to increase the wearing qualities.

Breather: An opening in the crankcase of a gas engine to permit pressure therein to remain equal during the movement of the pistons.

British Thermal Unit. The ordinary unit of heat. It is that quantity of heat required to raise the temperature of one pound of pure water one degree Fahrenheit at the temperature of greatest density of water.

Brougham Body: A closed-in automobile body having windows at the side doors, and in front, but with no extension of the roof over the front seat.

Brush Holder: In electrical machinery, an arrangement to hold one end of a connection flexible in contact with a moving part of the circuit.

B. T. U.: Abbreviation for *British Thermal Unit.*

Buckboard: A four-wheeled vehicle in which the body and springs are replaced by an elastic board or frame

Buckling: Irregularities in the shape of the plates of storage cells following a too rapid discharge.

Bumper: (1) A contrivance at the front of the car to minimize shock of collision; it consists of plungers working in tubes and gaining elasticity from springs. (2) A bar placed across the end of a car, usually the front end, to take the shock of collision and thus prevent damage to the car itself. A rubber or leather pad interposed between the axle and frame of a car.

Burner, "Torch" Igniter: A movable auxiliary vaporizer for starting the fire in steam automobile burners.

Bushing: A bearing lining. Usually made of anti-friction metal and capable of adjustment or renewal.

Bus-Pipe: A manifold pipe.

Butterfly Valve: A valve inserted in a pipe, usually circular and of nearly the same diameter as the pipe, designed to turn upon a spindle through its diameter and thus shut off or permit flow through the pipe. Usually employed for throttle valves and carbureter air valves.

Buzzer: (1) A name sometimes applied to the vibrator or trembler of a jump-spark ignition coil. (2) A device used in place of a horn, and consisting of a diaphragm which is made to vibrate rapidly by an electromagnet.

By-Pass: A small valve to provide a secondary passage for fluids passing through a system of piping.

C: Abbreviation for a centigrade degree of temperature.

Calcium Carbide: A compound of calcium and carbon used for the generation of acetylene by the application of water.

Calcium Chloride: A salt which dissolved in water is used as an anti-freezing solution.

Cam: A revolving disk, irregular in shape, fixed on a revolving shaft so as to impart to a rod or lever in contact with it an intermittent or variable motion.

Cam, Exhaust: A cam designed to operate the exhaust of an engine.

Cam, Ignition: A cam designed to operate the ignition mechanism. In magnetos it operates the make-and-break device.

Cam, Inlet: A cam designed to operate the inlet valve of an engine.

Camber: (1) The greatest depth of curvature of a surface. (2) The amount of bend in an axle designed to incline the wheels.

Camber of Spring: The maximum distance between the upper and lower parts of a spring under a given load.

Cambered Frame: A narrowing of the front of a motor car to permit of easier turning.

Cam Gear: The gear driving the camshaft of a gas engine. In a four-cycle engine this is the same as the two-speed gear.

Camshaft: A shaft by which the valve cams are rotated; also known as the *secondary shaft*.

Camshaft, Overhead: The camshaft carried along or above the cylinder heads, to operate overhead valves.

Camshaft Gears: The gears or train of gears by which the camshaft is driven from the crankshaft. Half-time gears, timing gears, distribution gears.

Canopy: An automobile top that can not be folded up.

Capacity of a Condenser: The quality of electricity or electrostatic charge. Of a storage battery, the amount of electricity which may be obtained by the discharge of a fully charged battery. Usually expressed in ampere hours.

Cape Hood: An automobile top which is capable of either being folded up or extended.

Car: A wheeled vehicle.

Carbide: See "Calcium Carbide".

Carbide Feed: A type of acetylene generator in which the calcium carbide is fed into the water.

Carbon Bridge: Formation of soot between points of spark plug.

Carbon Deposit: A deposit upon the interior of the combustion chamber of a gasoline engine composed of carbonaceous particles from the lubricating oil, too rich fuel mixture, or road dust.

Carbon Remover: A tool or solution for removing carbon deposits from the cylinder, piston, or spark plug of a gasoline engine.

Carbonization: The deposit of carbon.

Carbureter: An appliance for mixing an inflammable vapor with air. It allows air to be passed through or over a liquid fuel and to carry off a portion of its vapor mixed with the air, forming an explosive mixture.

Carbureter, Automatic: A carbureter so designed that either the air supply alone or both the air and gasoline supplies are regulated automatically.

Carbureter, Constant-Level: A carbureter the level of the gasoline in which is maintained automatically at a constant height. A float-feed carbureter.

Carbureter, Exhaust-Jacketed: A carbureter whose mixing chamber is heated by the circulation of exhaust gas.

Carbureter, Multiple-Jet: A carbureter having more that one spray nozzle or jet.

Carbureter, Water-Jacketed: A carbureter whose mixing chamber is heated by the circulation of water from the cooling system.

Carbureter Float: A buoyant part of the carbureter designed to float in the gasoline and connected to a valve controlling the flow from the fuel tank, designed to maintain automatically a constant level of the gasoline in the flow chamber.

Carbureter Float Chamber: A reservoir containing the float and in which a constant level of fuel is maintained.

Carbureter Jet: The opening through which liquid fuel is ejected in a spray from the standpipe of a carbureter nozzle.

Carbureter Needle Valve: A valve controlling the flow of fuel from the flow chamber to the standpipe.

Carbureter Nozzle: See "Carbureter Jet".

Carbureter Standpipe: A vertical pipe carrying the nozzle.

Carburetion: The process of mixing hydrocarbon particles with the air. The action in a carbureter.

Cardan Joint: A universal joint or Hooke's coupling.

Cardan Shaft: A shaft provided with a Cardan joint at each end.

Casing: The shoe or outer covering of a double-tube automobile tire.

Catalytic Ignition: See "Ignition, Catalytic".

Cell: One of the units of a voltaic battery.

Cell, Dry: See "Dry Cell".

Cell, Storage: See "Accumulator".

Cellular Radiator: A radiator in which the openings between the tubes are in the form of small cells. The same as a *honeycomb radiator*.

Cellular Tire: A cushion tire which is divided into compartments or cells.

Center of Gravity: That point in a body, which, if the body were suspended freely in equilibrium, would be the point of application of the resultant forces of gravity acting upon the body.

Center Control: The location of the gear-shift and emergency brake levers of a car in the center of a line parallel to the front of the front seat.

Centigrade Scale: The thermometer scale invented by Celsius. Used universally in scientific work.

Century. In automobiling, a hundred-mile run.

C. G. S. System: Abbreviation for centimeter-gram-second system of measurement; the standard system in scientific work.

Chain, Drive: A heavy chain by which the power from the motor may be transmitted to the rear wheels of an automobile.

Chain, Roller: A sprocket chain, the cross bars of whose links are rollers.

Chain, Silent: See "Silent Chain".

Chain, Tire: A small chain fastened about the tire to increase traction and prevent skidding.

Chain Wheel: A sprocket wheel for the transmission chains of a motor-driven vehicle.

Change-Speed Gear: See "Gear, Change-Speed".

Change-Speed Lever: See "Lever, Change-Speed".

Charge: The fuel mixture introduced into the cylinder of a gas engine. The act of storing up electric energy in an accumulator.

Charging: The passing of a current of electricity through a storage cell.

Charles' Law of Gases: See "Gases, Gay Lussac's Law of".

Chassis. The mechanical features of a motor car assembled, but without body, fenders, or other superstructure not essential to the operation of the car.

Chauffeur: In America this term means the paid driver or operator of a motor car. The literal translation from the French means stoker or fireman of a boiler.

Check, Steering: See "Steering Check".

Check Valve: An automatic or non-return valve used to control the admission of feed water in the boiler, etc.

Choke: The missing of explosions or poor explosions due to too rich mixture.

Circuit, Primary: See "Primary Circuit".

Circuit, Secondary: See "Secondary Circuit".

Circuit Breaker: A device installed in an electric circuit and intended to open the circuit automatically under predetermined conditions of current flow.

Circulating Pump: A pump which keeps a liquid flowing through a series of pipes which provides a return circuit. In a motor car, water and oil circulation is maintained by circulating pump.

Circulation Pump: A mechanically operated pump by which the circulation of water in the cooling system is maintained.

Circulating System: The method or series of pipes through which a continuous flow of water or oil is maintained and in which the liquid is sent through the system over and over.

Clash Gear: A sliding change-speed gear.

Clearance: (1) The distance between the road surface and the lowest part of the under-body of an automobile. (2) The space between the piston of an engine when at the extremity of its stroke, and the head of the cylinder.

Clearance, Valve: See "Valve Clearance".

Clearance Space: The space left between the end of the cylinder and the piston plus the volume of the ports between the valves and the cylinder.

Clevis: The fork on the end of a rod.

Clevis Pin: The pin passing through the ends of a clevis and through the rod to which the clevis is joined.

Clincher Rim: A wheel rim having a turned-in edge on each side, forming channels. Into this the edge or flange of the tire fits, the air pressure within locking the tire and rim together.

Clincher Tire: A pneumatic tire design to fit on a clincher rim.

Clutch: A device for engaging or disconnecting two pieces of shafting so that they revolve together or run free as desired.

Clutch Cone: A clutch whose engaging surfaces consist of the outer surface of the frustrum of one cone and the inner surface of the frustrum of another.

Clutch, Contracting-Band: A clutch consisting of a drum and band, the latter contracting upon the former.

Clutch, Dry-Plate: A clutch whose friction surfaces are metal plates, not lubricated.

Clutch, Expanding-Band: A clutch consisting of a drum and band, the latter expanding within the former.

Clutch, Jaw: A clutch whose members lock end to end by projections or jaws in one entering corresponding depressions in the other.

Clutch, Multiple-Disk: A clutch whose friction surfaces are metal plates or disks, alternate disks being attached to one member and the rest to the other member of the drive.

Clutch Brake: A device designed to stop automatically the rotation of the driven member of a clutch after disengagement from the driving member.

Clutch Lining: The wearing surface of a clutch. This may be easily removed and replaced when worn.

Clutch Pedal: The pedal by which the clutch may be disengaged, engagement being obtained automatically by means of a spring.

Clutch Spring: A spring arranged to either hold a clutch out of gear or throw it into gear.

Coasting: The movement of the car without constant applications of the motive power, as in running downhill with the aid of gravity or on the level, through the momentum obtained by previous power applications.

Cock, Priming: A small cock, usually operated by a lever, for admitting gasoline to the carbureter to start its action.

Coil, Induction: See "Spark Coil".

Coil, Non-Vibrator: A coil so designed that it will supply a sufficient spark for the ignition with one make and break of the primary circuit.

Coil, Primary: See "Primary Coil".

Coil, Secondary: See "Secondary Spark Coil".

Coil, Spark: See "Spark Coil".

Coil, Vibrator: A spark coil with which is incorporated an electromagnetic vibrator to make and break the primary circuit.

Coil Vaporizer: An auxiliary vaporizer to assist in starting a steam boiler. It is a coil of tubing into which liquid gasoline is admitted and burned to start the generation of gas in the main burner.

Cold Test: The temperature in degrees Fahrenheit at which a lubricant passes from the fluid to the solid state.

Combustion Chamber: That part of an explosive motor in which the gases are compressed and then fired, usually by an electric spark.

Combustion Space: See "Clearance" and "Clearance Space".

Commercial Car: A motor-driven vehicle for commercial use, such as transporting passengers or freight.

Commutator: In the ignition system of an explosive motor, the commutator is a device to automatically complete the circuit of each of a number of cylinders in succession.

Commutator of Dynamo or Motor: That part of a dynamo which is designed to cause the alternating current produced in the armature to flow in one direction in the external circuit; in a motor, to change the direct current in the external circuit into alternating current.

Compensating Carbureter: An automatic attachment to a carbureter controlling either air or fuel admission, or both, so that the proportion of one to the other is always maintained under any vibration of power required.

Compensating Gear: See "Differential Gear".

Compensating Joint: See "Universal Joint".

Compound Engine: A multiple-expansion steam engine in which the steam is expanded in two stages, first in the high-pressure cylinder and then in the low-pressure cylinder.

Compression: (1) That part of the cycle of a gas engine in which the charge is compressed before ignition; in a steam engine it is the phase of the cycle in which the pressure is increased, due to compression of the exhaust steam behind the piston. (2) The greatest pressure exerted on the gas in the compression chamber.

Compression Chamber: The clearance volume above the piston in a gas engine; also called "Compression Space".

Compression Cock: See "Compression-Relief Cock".

Compression Line: The line on an indicator diagram corresponding to the phase of the cycle in which the gas is compressed.

Compression-Relief Cock: A small cock by which the compression chamber of an internal-combustion motor may be opened to the air and thus allow the compression in the cylinder to be relieved to facilitate turning by hand, or *cranking*.

Compression Space: See "Compression Chamber".

Compression Tester: A small pressure gage by which the degree of compression of the mixture in a gas-engine cylinder may be tested.

Compressor, Air: See "Air Compressor".

Condenser: (1) In a steam motor, an apparatus in which the exhaust steam is converted back into water. (2) A device for increasing the electric capacity of a circuit. Used in an ignition circuit to increase the strength of the spark.

Cone Bearing: A shaft bearing in which the shaft is turned to a taper and the journal turned to a conical or taper form.

Cone Clutch: A friction clutch in which there are two cones, one fitting within the other.

Connecting Rods: The part of an engine connecting the piston to the crank, and by means of which a reciprocating motion of the piston is converted into the rotary motion of the crank.

Constricting Band Brake: See "Brake, Constricting Band".

Constricting Clutch: A friction clutch in which a band is tightened around a drum to engage it.

Contact Breaker: A device on some forms of gasoline motors having an induction coil of the single jump-spark type, to open and close the electric circuit of the battery and coil at the proper time for the passage of the arc or spark at the points of the spark plug.

Contact Maker: See "Contact Breaker".

Continental Drive: Double-chain drive.

Control: The levers, pedals, etc., in general with the speed and direction of a car is regulated by the driver. In speaking of right, left, or center control, the gearshift and emergency brake levers only are meant.

Control, Spark: Method of controlling the power of an engine by varying the point in the stroke at which ignition takes place.

Control, Throttle: Method of governing the power of the engine by altering the area of the passage leading to the admission valve so that the amount of the fuel introduced into the cylinder is varied.

Controller, Electric: Apparatus for securing various combinations of storage cells and of motors so as to vary the speed of the car at will.

Converter: A device for changing alternating current into direct current for charging storage batteries, etc. Converters may be any of three kinds: rotary, electrolytic, or mercury-vapor. The mercury-vapor converter is most widely used.

Convertible Body: An automobile body which may be used in two or more ways, usually as an open or closed carriage, or in which several seats may be concealed, and raised to increase the seating capacity.

Cooling Fan: Fan used in automobiles to increase the current of air circulating around the cylinders, or through the radiator.

Cooling System: The parts of a gas engine or motor car by which the heat is generated in the cylinder by the combustion of the fuel mixture. See "Water Cooling" and "Air Cooling".

Cork Inserts: Pieces of cork inserted in friction surfaces of clutches or brakes to give softer action.

Cotter Pin: A split metal pin designed to pass through holes in a bolt and nut to hold the former in place.

Coulomb: The unit of measure of electrical quantity. Sometimes called "Ampere Second". It is equivalent to the product of the current in amperes by the number of seconds current has been flowing.

Counterbalance: Weights attached to a moving part to balance that part.

Countershaft: An intermediate or secondary shaft in the power-transmission system.

Coupé: An enclosed body seating one or two passengers and the driver, all within.

Coupling, Flexible: See "Universal Joint".

Cowl: That portion of the body of the car which forms a hood over the instrument board or dash.

Cowl Tank: A fuel tank carried under the cowl and immediately in front of the dash.

Crank: A lever designed to convert reciprocating motion into rotating motion or *vice versa;* usually in the form of a lever formed at an angle with the shaft, and connected with piston by means of connecting rod.

Crank, Starting: A handle made to fit the projecting end of the crankshaft of a gas engine, so that the engine may be started revolving by hand.

Crankcase: The casing surrounding the crank end of the engine.

Crankcase Explosion: Explosion of unburned gases in the crankcase.

Crank Chamber: The enclosed space of small engines in which the crank works.

Cranking: The act of rotating the motor by means of a handle in order to start it. Turning the flywheel over a few times causes the engine to take up its cycle, and after an explosion it continues to operate.

Crankpin: The pin by which the connecting rod is attached to the crank.

Crankshaft: The main shaft of an engine.

Crankshaft, Offset: A crankshaft whose center line is not in the same plane as the axis of its cylinders.

Creeping of Pneumatic Tires: The tendency of pneumatic tires to push forward from the ground, and thus around the rim, in the effort to relieve and distribute the pressure.

Cross Member: A structural member of the frame uniting the side members.

Crypto Gear: See "Planetary Gear".

Crystallization. The rearrangement of the molecules of metal into a crystalline form under continued shocks. This is often the cause of the breaking of the axles and springs of a motor car.

Cup, Priming: A small cup-shaped device provided with a cock, by which a small quantity of gasoline can be introduced into the cylinder of a gasoline engine.

Current: The rate of flow of electricity; the quantity of electricity which passes per second through a conductor or circuit.

Current Breaker: See "Contact Breaker".

Current Indicator: A device to indicate the direction of current flow in a circuit; a polarity indicator.

Current Rectifier: A device for converting alternating current into direct current. See "Converter".

Cushion Tire: See "Tire, Cushion".

Cut-Off, Gas Engine: That point in the cycle of an internal-combustion engine at which the admission of the mixture is discontinued by the closing of the admission valve.

Cut-Off, Steam Engine: That point in the cycle of a steam engine, or that point on an indicator diagram, at which the admission of steam is discontinued by the closing of the admission valve.

Cut-Out, Automatic: A device in a battery charging circuit designed to disconnect the battery from the circuit when the current is not of the proper voltage.

Cut-Out, Muffler: A device by which the engine is made to exhaust into the air instead of into the muffler.

Cut-Out Pedal: Pedal by means of which the engine is made to exhaust into the air instead of into the muffler.

Cycle: A complete series of operations beginning with the drawing in of the working gas, and ending after the discharge of the spent gas.

Cycle, Beau de Rochas: See "Beau de Rochas Cycle".

Cylinder: A part of a reciprocating engine consisting of a cylindrical chamber in which a gas is allowed to expand and move a piston connected to a crank.

Cylinder Bore: See "Bore".

Cylinder Cock: A small cock used to allow the condensed water to be drained away from the cylinder of a steam engine, usually called a *drain cock.*

Cylinder Head: That portion of a cylinder which closes one end.

Cylinder Jacket: See "Jacket, Water".

Cylinder Oil: Lubricant particularly adapted to the lubrication of cylinder walls and pistons of engines.

Dash: The upright partition of a car in front of the front seat and just behind the bonnet.

Dash Adjustment: Connections by which a motor auxiliary may be adjusted by a handle on the dash. Usually applied to carbureter adjustments.

Dash Coil: An induction coil for jump-spark ignition, having an element for each cylinder, with dash connections to the commutator on the engine or camshaft.

Dash Gage: A steam, water, oil, or electric gage placed upon the dash of the car.

Day Type of Engine: The two-cycle internal-combustion engine with an air-tight crankcase.

Dead Axle: See "Axle, Dead".

Dead Center: The position of the crank and connecting rod in which they are in the same straight line. There are two positions, and in these positions no rotation of the crankshaft is caused by pressure on the piston.

Decarbonizer: See "Carbon Remover".

Deflate: Reduction of pressure of air in a pneumatic tire.

Deflector: In a two-cycle engine, the curved plate on the piston head designed to cause the incoming charge to force out the exhaust gases and thus assist in scavenging.

Deflocculated Graphite: Graphite so finely divided that it remains in suspension in a liquid.

Demountable Rim: A rim upon which a spare tire may be mounted and carried, and so arranged that it may be easily and quickly taken off or put on the wheel.

Denatured Alcohol: See "Alcohol, Denatured".

Densimeter: See "Hydrometer".

Depolarizer: Material surrounding the negative element of a primary cell to absorb the gas which would otherwise cause polarizing.

Detachable Body: A body which may be detached from and placed upon the chassis.

Detachable Rim: See "Demountable Rim".

Diagram Indicator: See "Indicator Card".

Diagram, Jeantaud: A diagrammatic representation of the running gear of an automobile, showing it turning corners of various radii for the purpose of determining the front-axle and steering connections.

Diesel Gas Engine: Four-cycle internal-combustion engine in which the explosion of the charge is accomplished entirely by the temperature produced by the high compression of the mixture.

Differential, Bevel-Gear: A balance gear in which the equalizing action is obtained by means of bevel gears.

Differential, Spur-Gear: A differential gear in which the equalizing action is obtained by spur gears.

Differential Brake: See "Brake, Differential".

Differential Case: See "Differential Housing".

Differential Gear: A mechanism to permit driving the wheels and yet allow them to turn a corner without slipping. An arrangement such that the driving wheels may turn independently of each other on a divided axle, both wheels being under the control of the driving mechanism. Sometimes called *balance, compensating,* or *equalizing gear.*

Differential Housing: The case that encloses the differential gear.

Differential Lock: A device which prevents the operation of the differential gear, so that the wheels turn as if they were on a solid shaft.

Dimmer: An arrangement for lowering the intensity of, or reducing the glare from headlights.

Direct Current: A current which does not change its direction of flow, as the current from a battery or a direct-current generator. Distinguished from an alternating current, which reverses its direction many times a minute.

Direct Drive: Transmission of power from engine to the final driving mechanism at crankshaft speed.

Discharge: In a storage battery, the passage of a current of electricity stored therein. In the ignition circuit, the flow of high-tension current at the spark gap.

Disk Clutch: A clutch in which the power is transmitted by a number of thin plates pressed face to face.

Distance Rod: See "Radius Rod".

Distribution Shaft: See "Camshaft".

Distributor: That part of the ignition system which directs the high-tension current, to the respective spark plugs in the proper firing order.

Double Ignition: A method of ignition which comprises two separate systems, either of which may be used independently of the other, or both together as desired. Usually distinguished by two current sources and two sets of plugs.

Drag: That action of a clutch or brake which does not completely release.

Drag Link: That rod in a steering gear which forms the connection between the mechanism mounted on the frame and the axle stub, and transmits the movements of steering from steering post to wheels.

Drive Shaft: The shaft transmitting the motion from the change gears to the driving axle; the torsion rod.

Driving Axle: The axle of a motor car through which the power is transmitted to the wheels.

Driving Wheel: The wheel to which or by which the motion is transmitted.

Dry Battery: A battery of one or more dry cells.

Dry Cell: A primary voltaic cell in which a moist material is used in place of the ordinary fluid electrolyte.

Dual Ignition: An ignition system comprising two sources of current and one set of spark plugs.

Dust Cap: A metal cap to be screwed over a tire valve to protect the latter from dust and water.

Dynamo: The name frequently applied to a dynamo-electric machine used as a generator. Strictly, the term *dynamo* should be applied to both motor and generator.

Dynamometer: The form of equalizing gear attached to a source of power or a piece of machinery to ascertain the power necessary to operate the machinery at a given rate of speed and under a given load.

Earth: See "Ground".

Economizer, Gas: An appliance to be attached to a float-feed carbureter to improve the mixture by automatically governing the amount of air in the float chamber.

Eccentric: A disk mounted off-center on a shaft to convert rotary into reciprocating motion.

Economy, Fuel: The fuel economy of a motor is the relation between the heat units

in the fuel used in the motor and the work or energy given out by the motor.

Efficiency: The proportion of power obtained from a mechanism as compared with that put into it.

Efficiency of a Motor: The efficiency of a gasoline motor is the relation between the heat units consumed by the motor and the work of energy in foot-pounds given out by it. Electrical efficiency of a motor is the relation between the electrical energy put into the motor and the mechanical energy given out by it.

Ejector: An apparatus by which a jet of steam propels a stream of water in almost the same way as an injector, except that the ejector delivers it into a vessel having but little pressure in it.

Electric Generator: A dynamo-electric machine in which mechanical energy is transformed into electrical energy; usually called *dynamo*.

Electric Horn: An automobile horn electrically operated.

Electric Motor: A dynamo-electric machine in which electrical energy is transformed into mechanical energy.

Electric Vehicle: An automobile propelled by an electric motor, for which current is supplied by a storage battery carried in the vehicle.

Electrolyte: A compound which can be decomposed by electric current. In referring to storage batteries, the term electrolyte means the solution of sulphuric acid in water in which the positive and negative plates are immersed.

Electromagnet: A temporary magnet which obtains its magnetic properties by the action of an electric current around it and which is a magnet only as long as such current is flowing.

Electromotive Force: A tendency to cause a current of electricity to flow; usually synonymous with *potential, difference of potential, voltage*, etc.

Element: The dissimilar substances in a battery between which an electromotive force is set up, as the plates of a storage battery.

Emergency Brake: A brake to be applied when a quick stop is necessary; usually operated by a pedal or lever.

En Bloc: That method of casting the cylinders of a gasoline engine in which all the cylinders are made as a single casting. Block casting; monoblock casting.

End Play: Motion of a shaft along its axis.

Engine, Alcohol: An internal-combustion engine in which a mixture of alcohol and air is used as fuel.

Engine, Gasoline: An internal-combustion motor in which a mixture of gasoline and air is used as fuel.

Engine, Kerosene: An internal-combustion engine in which a mixture of kerosene and air is used as fuel.

Engine, Steam: An engine in which the energy in steam is used to do work by moving the piston in a cylinder.

Engine Primer: A small pump to force fuel into the carbureter.

Engine Starter: An apparatus by which a gasoline engine may be started in its cycle of operations without use of the starting crank. It belongs usually to one of four classes: (1) Mechanical or spring actuated, such as a coil spring wound up by the running of the engine or a strap around the flywheel; (2) fluid pressure, such as compressed air or exhaust gases induced into the cylinder to drive the piston through one cycle; (3) the electric system, in which a small motor is used to turn the engine over; (4) combinations of these.

Epicyclic Gear: See "Planetary Gear".

Equalizing Gear: See "Differential Gear".

Exhaust: The gases emitted from a cylinder after they have expanded and given up their energy to the piston; the emission of the exhaust gases.

Exhaust, Auxiliary: See "Auxiliary Exhaust".

Exhaust Horn: An automobile horn in which the sound is produced by the exhaust

Exhaust Lap: The extension of the inside edges of a slide valve to give earlier closing of the exhaust. Also called *inside lap*.

Exhaust Manifold: A large pipe into which the exhaust passages from all the cylinders open.

Exhaust Port: The opening through which the exhaust gases are permitted to escape from the cylinder.

Exhaust Steam: Steam which has given up its energy in the cylinder and is allowed to escape.

Exhaust Stroke: The stroke of an internal-combustion motor during which the burned gases are expelled from the cylinder.

Exhaust Valve: A valve in the cylinder of an engine through which the exhaust gases are expelled.

Expanding Clutch: A clutch in which a split pulley is expanded to press on the inner circumference of a ring which surrounds it, and thus transmits motion to the ring.

Expansion, Gas Engine: That part of the cycle of a gas engine immediately after ignition, in which the gas expands and drives the piston forward.

Expansion, Steam Engine: That portion of the stroke of the steam engine in which the steam is cut off by the valves and continues to perform work on the piston, increasing in volume and decreasing in pressure.

Explosive Motor: See "Internal-Combustion Motor".

Fan, Cooling: A mechanically operated fan for producing a current of air for cooling the radiator or cylinder of a gas engine.

Fan, Radiator: A mechanically operated rotary fan used to induce the flow of air through the radiator to facilitate the cooling of the water.

Fan Belt: The belt which drives the cooling fan.

Fan Pulley: A pulley permanently attached to the fan and over which the fan belt runs to drive it.

Fat Spark: A short, thick, ignition spark.

Feed Pump: A pump by which water is delivered from the tank to the boiler of a steam car.

Feed Regulator: A device to maintain a uniform water level in a steam boiler by controlling the speed of the feed pump.

Feed-Water Heater: An apparatus for heating the boiler-feed water, either by means of a jet of steam or steam-heated coils.

Fender: A mud guard or shield over the wheels of a car.

Field, Magnetic: Space in the neighborhood of the poles of a magnet in which the magnetism exerts influence. Field also refers to the coils which produce the magnetism in an electromagnet.

Fierce Clutch: A clutch which cannot be engaged easily. A grabbing clutch.

Filler Board: Woodwork shaped to fill the space between the lower edge of the windshield and the dash.

Fin: Projections cast on the cylinders of a gas engine to assist in cooling.

Final Drive: That part of a car by which the driving effort is transmitted from the parts of the transmission carried on the frame to the transmission parts on the rear axle. The propeller shaft in a shaft-drive car.

Fire Test: A test of a lubricant to determine the temperature at which it will burn.

Firing: (1) Ignition of the charge in a gas engine. (2) The act of furnishing fuel under the boiler of a steam engine.

First Speed: That combination of transmission gears which gives the lowest gear ration forward. Slow speed; low speed.

Flash Boiler: A boiler arranged to generate highly superheated steam almost instantaneously, by allowing water to come in contact with very hot metal surfaces.

Flash Generator: See "Flash Boiler".

Flash Point: The temperature at which an oil will give off a vapor that will ignite when a flame comes in contact with it.

Flash Test: A test to determine the flash point of oils.

Flexibility: In an engine the ability to do useful work through a range of speeds.

Flexible Coupling: See "Universal Joint".

Flexible Shaft: A pliant shaft which will transmit considerable power when revolving.

Flexible Tubing: A tube for the conduction of liquids or gases, which may be bent at a small radius without leaking.

Float Carbureter: A carbureter for gasoline engines in which a float of cork or hollow metal controls the height of the liquid in the atomizing nozzle. Sometimes called *float-feed carbureter.*

Float Valve: An automatic valve by which the admission of a liquid into a tank is controlled through a lever attached to a hollow sphere which floats on the surface of the liquid and opens or closes the valve according as it is high or low.

Floating Axle: See "Axle, Floating".

Floating the Battery on the Line: Charging the battery while it is giving out current.

Flooding: Excessive escape of fuel in a carbureter from the spraying nozzle.

Flushing Pin: In a float-feed carbureter, a pin arranged to depress the float in priming. Also called *primer* and *tickler*.

Flywheel: A wheel upon the shaft of an engine which, by virtue of its moving mass, stores up the energy of the gas transmitted to the flywheel during the impulse stroke and delivers it during the rest of the cycle, thus producing a fairly constant torque.

Flywheel Marking: Marks on the face of a flywheel to indicate the time of valve opening and closing and thus assist in valve setting.

Foaming: See "Priming".

Fore Carriage: A self-propelled vehicle in which the motor is carried on the forward trucks, and propelling and steering is done with the forward trucks.

Fore-Door Body: An automobile body having doors in the forward compartment.

Four-Cycle or Four-Stroke Cycle: The cycle of operations in gas engines occupying two complete revolutions or four strokes.

Four-Wheel Drive: Transmission of driving effort to all four wheels.

Fourth Speed: That combination of transmission gears which gives the fourth from the lowest gear ratio forward. Usually the highest speed.

Frame: The main structural part of a chassis. It is carried upon the axles by the springs and carries the different elements of the car.

Frame Hangers: See "Body Hangers".

Free Wheel: A wheel so arranged that it can rotate more rapidly than the mechanism which drives it.

Friction: The resistance existing between two bodies in contact which tends to prevent their motion on each other.

Friction Clutch: A device for coupling and disengaging two pieces of shafting while in motion, by the friction of cones or plates on one another.

Friction Disk: The thin plate used in a disk or friction clutch. See "Disk Clutch".

Friction Drive: A method of transmitting power or motion by frictional contact.

Fuel: A combustible substance by whose combustion power is produced. Gasoline and kerosene are the chief automobile fuels.

Fuel Economy. See "Economy, Fuel".

Fuel Feed, Gravity: See "Gravity Fuel Feed".

Fuel Feed, Pressure: See "Lubrication, Force-Feed."

Fuel Feed, Vacuum. See "Vacuum Fuel Feed".

Fuel-Feed Regulator: A device in the fuel system of steam motor by which the rate of flow of fuel to the burner is automatically regulated.

Fuel Level: The height of the top of the fuel in the float chamber of a carbureter.

Fuel-Level Indicator: An instrument either permanently connected to the fuel tank or which may be inserted thereon to indicate the quantity of fuel in the tank.

Fuel Tank, Auxiliary: A tank designed to hold a supply of fuel in addition to that carried in the main shaft.

Fuse: A length of wire in an electric circuit designed to melt and open the circuit when excess current flows through it and thus prevent damage to other portions of the circuit.

Fusible Plug: A hollow plug filled with an alloy which melts at a point slightly above the temperature of the steam in a boiler, as when the water runs low, thus putting out the fire and preventing the burning out of the boiler.

Gage: (1) Strictly speaking, a measure of, or instrument for determining dimensions or capacity. Practically, the term refers to an instrument for indicating the pressure or level of liquids, etc. (2) The distance between the forward or rear wheels measured at the points of contact of the tires on the road. Tread; track.

Gage Cock: A small cock by which a pipe leading to a gage may be opened or closed.

Gage Lamp: Lamp, usually electric, placed above or near the gages to enable them to be read at night.

Gage, Oil: See "Oil Gage".

Gage, Tire: See "Tire-Pressure Gage".

Gap: In automobiles, the spark gap.

Garage: A building for storing and caring for automobiles.

Garage, Portable: A garage which may be moved from one place to another either as a whole or in sections.

Gas: Matter in a fluid form which is elastic and has a tendency to expand indefinitely with reduction in pressure.

Gas Economizer: See "Economizer".

Gas Engine: An internal-combustion motor in which a mixture of gas and air is used as fuel. The term is also applied to the gasoline engine.

Gas Engine, Otto: A four-stroke cycle engine developed by Otto and using the hot-tube method of ignition.

Gas Generator: An apparatus in which a gas is generated for any use.

Gas Lamp: See "Acetylene Lamp".

Gases, Boyle's Law of: See "Boyle's Law of Gases".

Gases, Gay Lussac's Law of: Called *Charles's Law* and the *Second Law of Gases*. Law defining the physical properties of gases at constantly maintained pressure. It states that at constant pressure the volume of gas varies with the temperature, the increase being in proportion to the change of temperature and volume of the gas.

Gasket: A thin sheet of packing material or metal used in making joints, piping, etc.

Gasoline: A highly volatile fluid petroleum distillate; a mixture of fluid hydrocarbons.

Gasoline-Electric Transmission: A system of propulsion in which a gasoline engine drives an electric generator, and the power is transmitted electrically to motors which drive the wheels.

Gasoline Engine: An internal-combustion motor in which a mixture of gasoline and air is used as a fuel.

Gasoline Primer: The valve on the carbureter of a gasoline engine by which the action of the engine can be started.

Gasoline-Tank Gage: A fuel-lever indicator for gasoline.

Gasoline Tester: A hydrometer graduated to indicate the specific gravity of gasoline, usually in degrees Baumé.

Gate: A plate which guides the gearshift lever in making speed changes.

Gather: Convergence of the forward portions of the front wheels. Toeing in.

Gay Lussac's Law of Gases: See "Gases, Gay Lussac's Law of".

Gear, Balance: See "Differential Gear".

Gear, Bevel: See "Bevel Gear".

Gear, Change-Speed: An arrangement of gear wheels which transmits the power of the motor to the differential gear at variable speeds independently of the motor speed.

Gear, Differential: See "Differential".

Gear, Fiber: A gear cut from a vulcanized fiber blank.

Gear, Helical: A gear whose teeth are not parallel to the axis of the cylinders.

Gear, Internal: A gear whose teeth project inward toward the center from the circumference of gear wheel.

Gear, Planetary: See "Planetary Gears".

Gear, Progressive: See "Progressive Change-Speed Gears".

Gear, Rawhide: A gear cut from a blank made up of compressed rawhide.

Gear, Selective: See "Selective Change-Speed Gears".

Gear, Timing: See "Timing Gears".

Gear, Worm: A helical gear designed for transmitting motion at angles, usually at right angles and with a comparatively great speed reduction.

Gearbox: The case covering the change-speed gears.

Gear Shifting: Varying the speed ration between motor and rear wheels by operating the change-speed gears.

Gear-Shift Lever: A lever by which the change-speed gears are shifted.

Geared-Up Speed: A speed obtained by an arrangement of gears in the gearset such that the propeller shaft rotates more rapidly than the crankshaft.

Gearset: See "Gear, Change-Speed".

Generator, Acetylene: See "Acetylene Generator".

Generator, Electric: See "Electric Generator".

Generator, Steam: A steam boiler.

Generator Tubing: Tubing by which acetylene is conducted from the generator to the lamp.

Gimbal Joint: A form of universal joint.

Gong: A loud, clear sounding bell, usually operated either electrically or by foot power.

Governor: A device for automatically regulating the speed of an engine.

Governor, Dynamo: A method of automatic control of the generator (usually an ignition generator, in automobile work) by which its speed is maintained approximately constant.

Governor, Hydraulic: A governor applied to engines cooled by a pump circulation of water in such a way that the throttle opening is controlled by the pressure of the water.

Governor, Spark: A method of automatically controlling the speed of the engine by varying the time of ignition. See "Governor".

Grabbing Clutch: See "Fierce Clutch".

Gradometer: An instrument for indicating the degree of the gradient or the per cent of the grade. It consists of a level with a graduated scale.

Graphite: One of the forms in which carbon occurs in matter. Also known as *black lead*

and *plumbago*. Used as a lubricant in powdered or flake form in the cylinders of explosive engines.

Gravity-Feed Oiling System: See "Lubrication, Gravity".

Gravity Fuel Feed: Supply of fuel to the carbureter from the tank by force of gravity.

Grease and Oil Gun: A syringe by means of which grease or oil may be introduced into the bearings of the machinery.

Grease Cup: A device designed to feed grease to a bearing by the compression of a hand screw.

Grid: A lead plate formed in the shape of a gridiron to sustain and act as a conductor of electricity for the active material in a storage battery.

Grinding Valves: See "Valve Grinding".

Gripping Clutch: See "Fierce Clutch".

Ground: An electric connection with the earth, or to the framework of a machine.

H

Half-Motion Shaft: See "Half-Time Shaft".

Half-Time Gear: See "Timing Gears".

Half-Time Shaft: The cam shaft of a four-cycle gas engine. It revolves at one-half the speed of the crankshaft.

Hammer Break: A make-and-break ignition system in which the spark is produced when the moving terminal strikes the stationary terminal like a hammer.

Header: A pipe from which two or more pipes branch. Manifold.

Heater, Automobile: A device for warming the interior of an automobile, usually electric, or by means of exhaust gases or jacket water.

High Gear: That combination of change-speed gears which gives the highest speed.

High-Tension Current: A current of high voltage, as the current induced in the secondary circuit of a spark coil.

High-Tension Ignition: Ignition by means of high-tension current.

High-Tension Magneto: A magneto which delivers high-tension current.

Honeycomb Radiator: A radiator consisting of many very thin tubes, giving it a cellular appearance.

Hood: (1) That part of the automobile body which covers the frame in front of the dash. The engine is usually under the hood. (2) The removable covering for the motor.

Hooke's Coupler: See "Universal Joint".

Horizontal Motor: A motor the center line of whose cylinder lies in a horizontal plane.

Horn, Automobile: A whistle or horn for giving warning of the approach of the automobile.

Horsepower: The rate of work or energy expended in a given time by a motor. One horsepower is the rate or energy expended in raising a weight of 350 pounds one foot in one second, or raising 33,000 pounds one foot in one minute.

Horsepower, Brake: The power delivered at the flywheel of an internal combustion engine as ascertained by a brake test.

Horsepower, Rated: The calculated power which may be expected to be delivered by a motor. In America the term usually refers to the horsepower as calculated by the S.A.E. formula.

Hot-Air Intake: The pipe or opening conveying heated air to the carburetor.

Hot-Head Ignition: The method of igniting the charge in a gas-engine cylinder by maintaining the head of the combustion chamber at a high temperature from the internal heat of combustion, as in the Diesel engine.

Hot-Tube Ignition: An ignition device formerly used for gas engines in which a closed metal tube is heated red-hot by a Bunsen flame. When the compressed gases in the cylinder are allowed to come in contact with this, ignition takes place.

Housing: A metallic covering for moving parts.

H.P.: (1) Abbreviation for *horsepower.* (2) Abbreviation for *high pressure.*

Hub Cap: A metal cap placed over the outer end of a wheel hub.

Hydrocarbons: Chemical combinations of carbon and hydrogen in varied proportions, usually distillates of petroleum, such as gasoline, kerosene, etc.

Hydrometer: An instrument by which the specific gravity or density of liquids may be ascertained.

Hydrometer Scale, Baumé's: An arbitrary measure of specific gravity.

I-Beam: Sometimes called *I-Section.* A structural piece having a cross section resembling the letter I. I-Beam front axle.

Igniter: An insulated contact plug without sparking points, used in make-and-break ignition with low-tension magneto.

Igniter, High-Speed: An igniter having a short spark coil for high-speed engines.

Igniter, Jump-Spark: A system of ignition in which is used a current of high pressure, which will jump across a gap in the high-pressure circuit, causing a spark at the gap.

Igniter, Lead of: Amount by which the ignition is advanced. See "Advanced Ignition".

Igniter, Primary: The apparatus in a primary circuit for making and breaking the circuit.

Igniter Spring: A spring to quickly break the circuit of a primary igniter.

Ignition, Advancing: See "Advanced Ignition".

Ignition, Battery: A system which gets its supply of current from a storage battery or dry cells. This system usually consists of a battery, a step-up coil, and a distributor for sending the current to the different spark plugs.

Ignition, Catalytic: Method of ignition for explosive motors based on the property of some metals, particularly spongy platinum, of becoming incandescent when in contact with coal gas or carbonized air.

Ignition, Double: See "Double Ignition".

Ignition, Dual: See "Dual Ignition".

Ignition, Fixed: Ignition in which the spark occurs at a given point in the cycle and cannot be changed from that point at the will of the operator except by retiming the ignition system. Fixed spark.

Ignition, Generator: Ignition current which is furnished by a combination lighting generator and magneto. The generator is

fitted with an interrupter and distributor. Sometimes refers to system in which a generator charges a battery and the latter furnishes the ignition current in connection with a coil and distributor.

Ignition, High-Tension: Sometimes called jump-spark. Ignition which is effected by means of a high-tension or high-voltage current which is necessary to jump a gap in the spark plug.

Ignition, Hot-Head: See "Hot-Head Ignition".

Ignition, Jump-Spark: See "Ignition, High-Tension".

Ignition, Low-Tension: See "Ignition, Make-and-Break".

Ignition, Make-and-Break: A system in which the spark is produced by the breaking or interruption of a circuit, the break occurring in the combustion space of the cylinder. The current used is of low-voltage, hence the synonym, low-tension ignition.

Ignition, Magneto: Ignition produced by an electric generator, called a magneto, which is operated by the gas engine for which it furnishes current. Dynamo ignition. Generator ignition.

Ignition, Master Vibrator: A system which uses as many non-vibrator coils as there are cylinders, and one additional coil, called the master vibrator, for interrupting the primary circuit for all coils. The master vibrator also is used with vibrator coils in which the vibrators are short-circuited.

Ignition, Premature: Ignition occurring so far before the top dead center mark that the explosion occurs before the piston has reached upper dead center.

Ignition, Primary: An ignition system in which a low-tension current flows through a primary coil, the circuit being mechanically opened, allowing a high-tension spark to jump across the gap. See "Primary Coil".

Ignition, Retarding: Setting the spark of an internal-combustion motor so that the ignition will occur at a later part of the stroke.

Ignition, Self: Explosion of the combustible charge by heat other than that produced by the spark. Incandescent carbon will cause this. Motor overheating because of lack of water is another cause.

Ignition, Single: A system using but one source of current.

Ignition, Synchronized: Ignition by means of which the timing in each cylinder of a multicylinder engine is the same. In synchronized ignition the spark occurs at the same point in the cycle in each cylinder. This type of ignition is obtained with a magneto and is lacking in a multi-coil system using vibrator coils.

Ignition, Timing of: The adjustment of the ignition system so that ignition will take place at the desired part of the cycle.

Ignition, Two-Independent: See "Ignition, Double".

Ignition, Two-Point: A system comprising two ignition sources, or a double-distributor magneto, and two sets of spark plugs, both of which spark at the same time.

Ignition Distributor: See "Distributor."

Ignition Switch: A control or switch for turning the ignition current on and off voluntarily

I. H. P.: Abbreviation for *indicated horse power.*

Indicated Horsepower: (1) The horsepower developed by the fuel on the pistons, in contradistinction to brake horsepower. See "Horsepower, Brake". (2) The horsepower of an engine as ascertained from an indicator diagram.

Indicator: An instrument by which the working gas in an engine records its working pressure.

Indicator Card: A figure drawn by means of an indicator by the working gas in an engine. Also called *indicator diagram.*

Induction Stroke: The downstroke of a piston which causes a charge of mixture to be drawn into the cylinder.

Inflammation: The act or period of combustion of the mixture in the cylinder.

Inflate: To increase the pressure within a tire by forcing air into it.

Inflator, Mechanical Tire: A small power-driven air-pump for inflating the tire; either driven by gearing, chain, or belt from the engine shaft, or by friction from the flywheel.

Inherent Regulation: Expression applied to electric generators which use no outside means of regulating the output, the regulation being affected by various windings of the armature and fields.

Initial Air Inlet: See "Primary Air Inlet".

Initial Pressure: Pressure in a cylinder after the charge has been drawn in but not compressed.

Injector: A boiler-feeding device in which the momentum of a steam jet, directed by a series of conical nozzles, carries a stream of water into the boiler, the steam condensing within and heating the water which it forces along.

Inlet, Valve: The valve which controls the inlet port and so allows or prevents mixture from passing to the cylinder.

Inlet Port: Passage or entrance in the cylinder wall through which the fuel mixture is taken. Sometimes called intake port.

Inlet Manifold: Sometimes called intake manifold or header. A branched pipe connected to the mixing chamber at one end and at the branch ends to the cylinders so as to communicate with the inlet ports.

Inlet Manifold, Integral: A manifold or header cast integral with the cylinder.

Inner-Tire Shoe: A piece of leather or rubber placed within the tire to protect the inner tube.

Inner Tube: A soft air-tight tube of nearly pure rubber, which fits within a felloe upon the casing.

Inside Lap: See "Exhaust Lap".

Intake Manifold: The large pipe which supplies the smaller intake pipes from each cylinder of a gas engine.

Intake Pipe: Sometimes made synonymous with inlet manifold. Correctly, the pipe from the carbureter to the inlet manifold.

Intake Stroke: See "Induction Stroke".

Intensifier: See "Outside Spark Gap".

Intermediate Gear: A gear in a change-speed set between high and low. In a three-speed set it would be second speed. In a four, either second or third.

Intermediate Shaft: See "Shaft, Intermediate".

Internal-Combustion Motor: Any prime mover in which the energy is obtained by the combustion of the fuel within the cylinder.

Internal Gear: See "Gear, Internal".

Interrupter: See "Vibrator".

Jack: A mechanism by which a small force exerted over a comparatively large distance is enabled to raise a heavy body. Used for raising the automobile axle to remove the weight from the wheels.

Jacket, Water: A portion of the cylinder casting through which water flows to cool the cylinder.

Jacket Water: The cooling water circulating in a water-cooling system.

Jackshaft: Shaft used in double-chain drive vehicles. Shaft placed transversely in the frame and driving from its ends chains which turn the rear wheels mounted on a dead axle.

Jeantaud Diagram: See "Diagram, Jeantaud".

Joint Knuckle: See "Swivel Joint."

Joule's Law of Gases: See "Gases, Joule's Law of".

Jump Spark: A spark produced by a secondary jump-spark coil.

Jump Spark, Circuit Maker: A mechanically operated switch by which the circuit in a jump-spark ignition system is opened and closed.

Jump-Spark Coil: An electrical transformer and interrupter, consisting of a primary winding of a few turns of coarse wire surrounding an iron core, and a secondary winding consisting of a great number of turns of very fine wire. The condenser is usually combined with this. Also known as *secondary spark coil.*

Jump-Spark Igniter: See "Igniter, Jump-Spark".

Jump-Spark Plug: See "Spark Plug".

Junction Box: A portion of an electric-lighting system to which all wires are carried for the making of proper connections.

Junk Ring: A packing ring used in sleeve-valve motors. It has the same functions as a piston ring. See "Piston Ring".

K

Kerosene: A petroleum product having a specific gravity between 58° and 40° Baumé. It is used as a fuel in internal-combustion engines and can often be used in gasoline engines by starting the engine on gasoline, then switching to kerosene.

Kerosene Burner: A burner especially adapted to use kerosene as a fuel.

Kerosene Engine: An engine using kerosene as fuel.

Key: A semicircular or oblong piece of metal used to hold a member firmly on a revolving shaft so as to prevent the member from rotating.

Key, Baldwin: A key with an oblong section.

Key, Woodruff: A key with a semicircular section.

Keyway: Slot in a rotating member used to hold the kev

Kick Switch: Ignition switch mounted so that the driver can operate it with the foot.

Kilowatt: An electrical unit equal to 1000 watts.

Knuckle Joint: See "Swivel Joint".

Labor: The jerky operation of an engine. The engine is said to labor when it cannot pull its load without misfiring or jerking.

Lag, Combustion: The time between the instant of the spark occurrence and the explosion.

Lag, Ignition: The time between the instant of spark occurrence and the time at which the spark mechanism producing it begins to act.

Lamp, Trouble: Sometimes called inspection lamp. A small electric bulb carried in a suitable housing, and attached to a long piece of lamp cord. Used for inspecting parts of the car.

Lamp Bulb: The incandescent bulb used in a lamp.

Lamp Bracket: A support for a lamp.

Lamp Lighter: An apparatus for lighting gas lamps by electricity. The lamps are usually so arranged that by pushing the button the gas is turned on and the spark made at the same time.

Landaulet: A type of car which may be used as an open or closed car. The rear portion of the body may be folded down like a top.

Landaulet Body: An automobile body resembling a limousine body, but having a cover fitted to the back, which may be let down, leaving the back open. The top generally extends over the driver.

Lap: To make parts fit perfectly by operating them with an abrasive, such as ground glass, between the rubbing surfaces. To finish.

Lap of Steam Valves: In the slide valve of a steam engine, the amount by which the admission edges overlap the steam port when the valve is central with the cylinder case.

Layshaft: A countershaft or secondary shaft of a gearset operated by the main or shifter shaft.

Lead, or Lead Wire: Any wire carrying electricity.

Lead: In a steam engine the amount by which the steam port is opened when the piston is at the start of its stroke.

Lead Battery: See "Accumulator".

Lead of Igniter: See "Igniter, Lead of".

Lead of Valve: In an engine the amount by which the admission port is opened when the piston is at the beginning of the stroke; according as this is greater or less, the admission of working fluid is varied through several fractions of the stroke.

Lean Mixture: Fuel after leaving the carbureter, which contains too much air in proportion to the gasoline. Sometimes called thin mixture, rare mixture, or weak mixture.

Lever, Brake: See "Brake Lever."

Lever, Change-Speed: Lever by which the different combinations of change gears are made so as to vary the speed of the driving

wheels in relation to the speed of the engine; also called gearshift lever.

Lever, Spark: Lever by which the speed and power of the engine are controlled by adjusting the time of ignition.

Lever, Steering: See "Steering Lever".

Lever, Throttle: A lever by which the speed and power of the engine are controlled by adjusting the amount of mixture admitted to the cylinder.

Lever Lock: An arrangement for locking the gearshift lever in free position so that with the engine running the driving axle will not be driven.

Lift: The distance through which a poppet valve is moved in opening from fully-closed to fully-open position.

Lifting Jack: See "Jack".

Lighting Outfit, Electric: An outfit for electrically lighting an automobile. This usually consists of a dynamo, storage battery, and lamps and switchboard, with the necessary wiring and cut-outs.

Limousine Body: An enclosed automobile body having the front and sides with side doors. The top extends over the seat of the driver.

Liner: One or more pieces of metal placed between two parts so they may be adjusted by varying the thickness of the liner. Sometimes called a shim. Also refers to a tool used for lining up parts.

Liner, Laminated: A liner or shim made in a number of parts, the thickness being varied by removing or adding parts.

Lines of Force: See "Field, Magnetic".

Link Motion: In a steam engine, the name for the arrangement of eccentric rods, links, hangers, and rocking shafts by which the relative motion and position of the slide valves are changed at will, providing for varying rates of expansion of the steam and thus varying the speed for either forward or backward motion.

Live Axle: See "Axle, Live".

Lock, Auto Safety: A device arranged so that it is impossible to start the motor car except by the proper combination or key.

Lock Nut: A nut placed on a bolt immediately behind the main nut to keep the main nut from turning.

Lock Switch: A switch in the ignition circuit so arranged that it can not be thrown on except by the use of a key.

Lock Valve: A valve capable of being secured with lock and key.

Long-Stroke: A gas engine whose stroke is considerably greater than its bore.

Lost Motion: Sometimes called play or backlash. Looseness of space between two moving parts.

Louver: A slit or opening in the side of a hood or bonnet of a motor car. Used to allow air from the draft to escape. A ventilator.

Low Gear: The lowest speed gear. First speed in a change-speed set.

Low-Speed Adjustment: A carbureter adjustment which regulates the mixture when the motor is operating slowly, with little throttle opening.

Low-Speed Band: The brake or friction band which controls the low speed of a planetary change-speed set.

Low-Tension Current: A current of low voltage or pressure, such as is generated by dry cells, storage battery, or low-tension magneto.

Low-Tension Ignition: See "Ignition, Make-and-Break".

Low-Tension Magneto: A magneto which initially generates a current of low voltage.

Low-Tension Winding: The winding of a transformer or induction coil through which the primary or low-tension current flows.

Low Test: Gasoline which has a high density, thus giving a low reading on the Baumé scale. Low-grade gasoline.

Low-Water Alarm: An automatic arrangement by which notice is given that the water in the boiler is becoming too low for safety.

Lubricant: An oil or grease used to diminish friction in the working parts of machinery.

Lubrication: To supply to moving parts and their bearings grease, oil, or other lubricant for the purpose of lessening friction.

Lubrication, Circulating: A system in which the same oil is used over and over.

Lubrication, Constant-Level: A system in which the level in the crankcase is kept to a predetermined level by means of a pump.

Lubrication, Force-Feed: Method of lubricating the moving parts of an engine by forcing the oil to the points of application by means of a pump.

Lubrication, Gravity: Method of supplying oil to moving parts of an engine by having a reservoir at a certain height above the highest point to be lubricated and allowing the oil to flow to the points of application by gravity.

Lubrication, Non-Circulating: A system in which the same oil is used but once.

Lubrication, Pressure-Feed: See "Lubrication, Force-Feed".

Lubrication, Sight-Feed: System of lubrication in which the oil pipe to different points of application is led through a glass tube in plain sight; usually at a point on the dashboard.

Lubrication, Splash: Method of lubricating an engine by feeding oil to the crankcase and allowing the lower edge of the connecting rod to splash into it.

Lubricator: A device containing and supplying oil or grease in regular amounts to the working parts of the machine.

Lubricator, Force-Feed: A pump-like device which automatically forces oil to the moving parts.

M

Magnet: A piece of iron or steel which has the characteristic properties of being able to attract other pieces of iron and steel.

Magnet, Horseshoe: A magnet shaped like the letter U.

Magnet, Permanent: A magnet which when once charged retains its magnetism.

Magnetic Field: See "Field, Magnetic".

Magnetic Spark Plug: A spark plug used in a make-and-break system of ignition in which contact is obtained by means of a magnet.

Magneto: See "Ignition, Magneto".

Magneto: See "Magneto-Electric Generator".

Magneto, Double-Distributor: A magneto with two distributors feeding two sets of spark plugs, two in each cylinder and both sparking at once. See "Ignition, Two-Point."

Magneto, High-Tension: A magneto has two armature windings and requires no outside coil for the generation of high-tension current.

Magneto, Induction: A type of magneto in which the armature and fields are stationary and a rotator or spool-shaped piece of metal is used to break the lines of force.

Magneto, Low-Tension: See "Low-Tension Magneto".

Magneto, Rotating Armature: A magneto in which the armature winding revolves.

Magneto Bracket: A shelf or portion of the crankcase web used to support the magneto.

Magneto Coupling: A flexible joint which connects the magneto with a revolving motor shaft.

Magneto Distributor: See "Distributor".

Magneto-Electric Generator: A machine in which there are no field magnet coils, the magnetic field of the machine being due to the action of permanent steel magnets. Usually contracted to *magneto*.

Main Bearing: A bearing, used for supporting the crankshaft.

Manifold: A main pipe or chamber into which or from which a number of smaller pipes lead to other chambers. See "Intake Manifold", "Exhaust Manifold", and "Inlet Manifold".

Manometer: A device for indicating either the velocity or the pressure of the water in the cooling system of a gasoline motor.

Master Vibrator: A single vibrator which interrupts the current to each of a set of several spark coils in order.

Mean Effective Pressure: The average pressure exerted upon a piston throughout its stroke.

M. E. P.: Abbreviation for *mean effective pressure.*

Mercury Arc Rectifier: A mercury vapor converter. See "Mercury Vapor Converter".

Mercury Vapor Converter: An apparatus for converting alternating current into direct current by means of a bubble of mercury in a vacuum. The vapor of mercury possesses the property of allowing the flow of current in one direction only. Its principal use is for charging storage batteries.

Mesh: Two gears whose teeth are so positioned that one gear will drive the other are said to be in mesh.

Misfire: Failure of the mixture to ignite in the cylinder; usually due to poor ignition or poor mixtures.

Miss: The failure of a gas engine to explode in one or more cylinders. Sometimes called misfiring.

Mixing Chamber: A pipe or chamber placed between the carbureter and inlet manifold. Sometimes integral with the carbureter or manifold.

Mixing Tube: A tubular carbureter for a gas or gasoline engine.

Mixing Valve: A device through which air and gas are admitted to form an explosive mixture. The carbureter of a gasoline engine combines the mixing valve and vaporizer.

Mixture: The fuel of a gas engine, consisting of sprayed gasoline mixed with air.

Monobloc: Cast *en bloc* or in one piece. Refers usually to cylinders, which are cast two or more at once.

Motocycle: A trade name for a special make of motorcycle.

Motor, Electric: See "Electric Motor".

Motor, Gasoline: See "Gasoline Motor".

Motor, High-Speed: A gas engine whose rotative speed is very high and whose power output goes up with the speed to an unusual degree.

Motor, Horizontal: A gas engine whose cylinder axis lies in a horizontal plane.

Motor, I-head: A gas engine which has cylinders, a section of which resembles the letter I. This type has the valves in the head.

Motor, L-Head: A gas engine in which a section of cylinders resembles the letter L. The valves in this type are all on one side.

Motor, Long-Stroke: See "Long-Stroke Motor".

Motor, Non-Poppet: A gas engine whose valves are not of the poppet type. In this class is the Knight sleeve valve, the rotary valve, and the piston valve.

Motor, Overhead Valve: A motor with cylinders whose valves are in the head.

Motor, Piston Valve: A gas engine using valves which are in the form of pistons.

Motor, Poppet: A gas engine using poppet-type valves. See "Poppet Valve".

Motor, Revolving Cylinder: A motor whose cylinders revolve as a unit.

Motor, Rotary Valve: One in which the valves consist of slots cut out along cylindrical rods which rotate in the cylinder casting.

Motor, Sliding Sleeve: The Knight type motor in which thin sleeves slide up and down in the cylinder, the sleeves having ports which register with the inlet and exhaust manifolds.

Motor, T-Head: A gas engine with the valves on opposite sides of the cylinders, a section of which resembles the letter T.

Motor, V-Type: A motor whose cylinders are set on the crankcase so as to form an angle of 45 to 90 degrees between them.

Motor, Vertical: A motor with the cylinder axis in a vertical plane.

Motorcycle: A bicycle propelled by a gasoline engine.

Mud Guard: Metal or leather strips placed over the wheels to catch the flying mud and to prevent the clothing from coming in contact with the wheels when entering and leaving the car.

Muffler Cut-Out: See "Cut-Out, Muffler".

Muffler Cut-Out Pedal: See "Cut-Out Pedal".

Muffler Exhaust: A vessel containing partitions, usually perforated with small holes and designed to reduce the noise occasioned by the exhaust gases of an engine, by forcing the gases to expand gradually.

Muffler Explosion: Explosion of unburned gases in exhaust passages of the muffler, usually due to poor ignition or poor mixture.

Multiple Circuit: A compound circuit in which a number of separate sources or electrically operated devices, or both, have all their positive poles connected to a single positive conductor and all their negative poles to a single negative conductor.

N

N.A.A.M.: Abbreviation for National Association of Automobile Manufacturers.

Naphtha: A product of the distillation of petroleum used to some extent for marine engines.

Needle Valve: A valve in a carbureter used for regulating the amount of gasoline to flow in with the mixture.

Negative Plate: Plate of a storage battery to which current returns from the outside circuit.

Negative Pole: That pole of an electric source through which the current is assumed to enter or flow back into the source after having passed through the circuit external to the source.

Neutral Position: The position of the change-speed lever which so places the gears that the motor may run idle, the car remaining still.

Non-Deflatable Tire: See "Tire, Non-Puncturable".

Non-Freezing Solution: A solution placed into the radiator of a motor car to prevent the water therein from freezing. Alcohol and glycerine are the usual anti-freezing agents. See "Anti-Freezing Solution".

Non-Puncturable Tire: See "Tire, Non-Puncturable".

Non-Skid Device: See "Anti-Skid Device".

Odometer: (1) The mileage-recording mechanism of a speedometer. (2) An instrument to be attached to an automobile wheel to automatically indicate the distance traveled.

Odometer, Hub: A speed-recording device which is placed on the hub cap of a wheel..

Offset: Off center, as a crankshaft in which a line vertically through the crankpins does not coincide with a line vertically through the center of the cylinder.

Ohm: (1) Unit of electrical resistance. (2) Amount of electrical resistance. Such resistance as would limit the flow of electricity under an electromotive force of one volt to a current of one ampere.

Ohm's Law: The law which gives the relation between voltage, resistance, and current flow in any circuit. Expressed algebraically, $C=\frac{I}{R}$ where C is the current flowing in amperes, I the voltage and R the ohmic resistance.

Oil Burner: A burner equipped with an atomizer for breaking up liquid fuel into a spray.

Oil Engine: An internal-combustion motor using kerosene or other oil as fuel.

Oil Gage: (1) A gage to indicate the flow of oil in the lubricating system. (2) Used to show the level of oil in a compartment in the base of a gas engine.

Oil Gun: A cylinder with a long point and a spring plunger for squirting oil or grease into inaccessible parts of a machine.

Oil Pump: A small force pump providing a constant positive supply of oil under pressure; usually considered to be more reliable than a lubricator.

Oiler: An automobile device for oiling machinery.

Opposed Motor: A gasoline engine whose cylinders are arranged in pairs on opposite sides of the crankshaft, both connecting rods of each pair being connected to the same crank, so that the shock of the explosion in one will be balanced by the cushioning effect of the compression in the other. In general these motors are two-cylinder, horizontal.

Otto Cycle: See "Four-Stroke Cycle".

Outside Spark Gap: See "Spark Gap, Outside".

Overcharged: The state of the storage battery when it has been charged at too high a rate or for too great a length of time.

Overhead Camshaft: A camshaft which is placed above the cylinder of a gas engine.

Overhead Valves: See "Motor, Overhead Valve".

Overheating: The act of allowing the motor to reach an excessively high temperature due to the heat of combustion being not carried away rapidly enough by the cooling devices, or to insufficient lubrication. Overheating of a bearing is due to insufficient lubrication.

Packing: The material introduced between the parts of couplings, joints, or valves, to prevent the leakage of gas or liquids to or from them.

Panel, Charging: A small switchboard for charging a storage battery.

Parallel Circuit: See "Multiple Circuit".

Patch, Tire-Repair: Rubber strips for making repairs in punctured or ruptured tires.

Petcock: A control cock which when open allows gas or liquid to escape from the chamber to which it is attached.

Petrol: Word used in England for gasoline.

Picric Acid: Acid which may be added to gasoline to increase the motor efficiency. Gasoline will absorb about five per cent of its weight of picric acid.

Pin, Taper: A conically shaped pin.

Pinch: A cut in an inner tube caused by the tube being caught or pinched between the outer casing and the rim.

Pinion: (1) The smaller of any pair of gears. (2) A small gear made to run with a larger gear.

Piston: The hollow, cylindrical portion attached to the connecting rod of a motor. The reciprocating part which takes the strain caused by the explosion.

Piston Air Valve: A secondary air valve in the piston of earlier types of gas engines to compensate the imperfect operation of surface carbureters used with those engines and to secure the injection of a sufficient quantity of air to insure the combustion of the charge.

Piston Head: The top of the piston.

Piston Pin: A pin which holds the connecting rod to the piston.

Piston Ring: (1) A metal ring inserted in a groove cut into a piston assisting in making the latter tight in the cylinder. There are usually three rings on each piston. (2) Rings about the circumference of a piston, whose diameter is slightly greater than that of the piston. These are to insure closer fit and prevent wearing of the piston, as the wear is taken up by the rings which may be easily removed.

Piston Rod: Usually called connecting rod. The rod which connects the piston with the crankshaft.

Piston Skirt: The portion of a piston below the piston pin.

Piston Speed: The rate at which the piston travels in its cylinder.

Piston Stroke: The complete distance a piston travels in its cylinder.

Pitted: Condition of a working surface which has become covered with carbon particles which have been imbedded in the metal.

Planetary Gear: An arrangement of spur and annular gears in which the smaller gears revolve around the main shaft as planets revolve around the sun.

Planetary Transmission: A transmission system in which the speed changes are obtained by a set of planetary gears.

Plate: Part of a storage battery which holds active material. See "Negative Plate".

Pneumatic Tire: A tire fitted to the wheels of automobiles, consisting usually of two tubes, the outer of India rubber, canvas, and other resilient wear-resisting material, and the inner composed of nearly pure rubber which is inflated with compressed air to maintain the outer tube in its proper form under load.

Polarizing: Formation of gas at the negative element of a cell so as to prevent the action of the battery. This formation of gas is caused by the violent reaction taking place in a circuit of low resistance.

Pole Piece: A piece of iron attached to the pole of a magneto used in an electric generator.

Poppet Valve: A disk or drop valve usually seating itself through gravitation or by means of springs, and frequently opening by suction or cams.

Port: An opening for the passage of the working fluid in an engine.

Portable Garage: See "Garage, Portable".

Positive Connection: A connection by which positive motion is transmitted by means of a crank, bolt, or key, or other method by which slipping is eliminated.

Positive Motion: Motion transmitted by cranks or other methods in which slipping is eliminated.

Positive Plate: Plate in a storage battery, from which the current flows to the outside circuit.

Positive Pole: The source from which electricity is assumed to flow; the opposite of negative pole. In a magnet the positive pole is the end of the magnet from which the magnetic flux is assumed to emanate.

Pounding in Engine: Pounding noise at each revolution, usually caused by either carbon deposit, loose or tight piston, loose bearing or other part, or pre-ignition

Power Stroke: The piston stroke in a gas engine in which the exploded gases are expanding, thus pushing the piston downward.

Power Tire Pump: A pump which is operated by a gas engine and is used to inflate the tires of a motor car.

Power Unit: The engine with fuel, cooling, lubrication, and ignition systems, without the transmission or running gears. Sometimes the gearset and driving shaft are included by the term.

Pre-Ignition: See "Premature Ignition".

Premature Ignition: Ignition of fuel before the proper point in the cycle.

Pressure-Feed: See "Lubrication, Force-Feed".

Pressure Gage: A gage for indicating the pressure of a fluid confined in a chamber, such as steam in a boiler, etc.

Pressure Lubricator: A lubricating device in which the oil is forced to the bearings by means of a pump or other device for maintaining pressure.

Pressure Regulator: A device for maintaining the pressure of the steam in the principal pipe at a constant point irrespective of the fluctuations of pressure in the boiler.

Primary Air Inlet: The main or fixed air intake of a carbureter.

Primary Circuit: The circuit which carries low-tension current.

Primary Coil: A self-induction coil consisting of several turns of wire about an iron core.

Primary Spark Coil: An induction coil which has only a single winding composed of a few layers of insulated copper wire wound on a bundle of soft iron wires, known as the *core*, also as a *wipe*, or *touch, spark coil.*

Primer: A pin in a float-feed valve so arranged that it may depress the float in priming a gasoline engine. Also called *tickler* and *flushing pin.*

Priming: (1) The carrying of water over with the steam from the boiler to the engine, due to dirty water, irregular evaporation, or forced steaming. (2) Injecting a small amount of gasoline into the cylinder of a gasoline engine to assist in starting.

Priming Cock: A control cock screwed into the cylinder and which when open communicates with the combustion chamber allowing gasoline to be poured into the cylinder.

Progressive Change-Speed Gears: Change-speed gears so arranged that higher speeds are obtained by passing through all the intermediate steps and *vice versa.*

Prony Brake: A dynamometer to indicate the horsepower of an engine. A band encircles the flywheel of the engine and is secured to a lever, at the other end of which is a scale to measure the pull.

Propeller Shaft: The shaft which turns the rear axle of a motor car. The drive shaft.

Pump, Centrifugal: A pump with a hollow hub and curved blades which by centrifugal force throw water or oil into the system requiring it.

Pump, Circulation: See "Circulation Pump".

Pump, Fuel-Feed: A mechanically operated pump for insuring positive feed of fuel to the burner of a steam engine or carbureter of a gas engine.

Pump, Oil: See "Oil Pump".

Pump, Plunger: Sometimes called piston pump. One containing a piston which forces a liquid to a system.

Pump, Power Tire: See "Tire Pump".

Pump, Steam Boiler-Feed: See "Boiler-Feed Pump".

Pump, Water Circulating: See "Circulation Pump".

Pump Gear: A pump composed of two gears in mesh placed in a housing. When the gears revolve they carry oil or water, as the case may be, on their teeth, which deliver it to an outlet.

Puncture: The perforation of an inflated rubber automobile tire by some sharp substance on the roadbed.

Puncture-Closing Compound: A viscous compound placed within the inner tire tube to close the hole caused by a puncture.

Push Rod: A rod which operates the valves of a poppet-valve motor. A rod which imparts a pushing motion.

R

Race: (1) The parts upon which the balls of a ball bearing roll. (2) When referring to a gas engine, to operate at high speed without a load.

Racing Body: A low, light automobile body, having two seats with backs as low as possible; designed for large fuel capacity and very high speed.

Radiator: A device consisting of a large number of small tubes, through which the heated water from the jacket of the engine passes to be cooled, the heat being carried away from the metal of the radiator by air.

Radiator, Cellular: See "Honeycomb Radiator".

Radiator, Tubular: A radiator consisting of many tubes, through which water passes to be cooled.

Radiator Protector: See "Bumper".

Radius Rod: A bar in the frame of an automobile to assist in maintaining the proper distance between centers. Also called *distance rod.*

Rawhide Gear: Tooth gears, built up of compressed rawhide, used for high-speed drive. Sometimes a metal gear is merely faced with rawhide for the purpose of reducing noise.

Reach Rod: See "Radius Rod".

Reciprocating Parts: The parts such as pistons and connecting rods which have a reciprocating motion.

Rectifier, Alternating-Current: See "Current Rectifier".

Relief Cock: See "Compression-Relief Cock".

Removable Rim: See "Demountable Rim".

Resiliency: That property of a material by virtue of which it springs back or recoils on removal of pressure, as a spring.

Resistance, Electrical: (1) A part of an electric circuit for the purpose of opposing the flow of the current in the circuit. (2) The electrical resistance of a conductor is that quality of a conductor by virtue of which the conductor opposes the passage of electricity through its mass. Its unit is the *ohm.*

Retard: With reference to the ignition system, causing the spark to occur while the piston is retarding or moving downward on the working stroke.

Retarding Ignition: See "Ignition, Retarding".

Retarding the Spark: See "Ignition, Retarding".

Retread: To replace the tread of a pneumatic tire with a new one.

Reverse Cam: On a gasoline engine a cam so arranged that by reversing its motion or shifting it along its shaft it will operate the valves and cause the engine to reverse.

Reverse Gear: In a steam engine, a device by which the valves may be set to effect motion of the car in either direction. In a gasoline automobile, the reversing gear is usually incorporated with the change-speed gears.

Reverse Lever: A lever by which the direction of movement of the driving wheels may be reversed without reversing the engine. This is usually combined with the change-speed levers.

Rheostat: A device for regulating the flow of current in a closed electrical circuit by introducing a series of graduated resistances into the circuit.

Rim: The portion of a wheel to which a solid or pneumatic tire is fitted. A circular, channel-shaped portion attached to the wheel felloe.

Rim, Demountable: A rim which may be removed from the wheel easily in order that another with an inflated tire may take its place.

Rim, Quick-Detachable: A rim made of two or more parts so that the tire may be detached and attached quickly.

Rim, Removable: See "Demountable Rim".

Road Map: A map of a section or locality showing the best roads for motor-car travel, and usually the best stopping places and repair stations.

Roadster: A small motor car designed to be fairly speedy; usually has carrying capacity for an extra large quantity of fuel and supplies; generally seats two persons, with provision for one or two more, by the attachment of a rumble seat in the rear.

Rocker Arm: A pivoted lever used to operate overhead valves in a T-head motor.

Rod, Radius: See "Radius Rod".

Rod, Steering: See "Steering Rod".

Roller Bearings: See "Bearing, Roller".

Roller Chain: A chain whose links are provided with small rollers to decrease the friction and the noise.

Rotary Valve: A type of valve somewhat similar to the Corliss engine valve used on automobile motors.

Rumble: A small single seat to provide for an extra passenger on a two-seated vehicle. Usually detachable.

Runabout: A small two-seated vehicle, usually of a lower power and lower speed, as well as lower operating radius, than a roadster.

Running Board: A horizontal step placed below the frame and used to assist passengers in leaving and entering a motor car.

Running Gear: The frame, springs, motor, wheels, speed-change gears, axles, and machinery of an automobile, without the body; used synonymously with *chassis*.

Safety Plug: See "Fusible Plug".

Safety Valve: A valve seated on the top of a steam boiler, and loaded so that when the pressure of the steam exceeds a certain point the valve is lifted from the seat and allows the steam to escape.

Saturated Steam: The quality of the steam when no more steam can be made in the closed vessel without raising the temperature or lowering the pressure.

Scavenging: The action of clearing the cylinder of an internal-combustion motor of the burned-out gases.

Score: To burn, or abrade a moving part with another moving part.

Screw: An inclined plane wrapped around a cylinder; a cylinder having a helical groove cut in its surface.

Searchlight: A headlight designed to throw a very bright light on the road. Electricity or acetylene is usually used as an illuminant, and the lamp has a parabolic reflector and may be turned to throw the light in any direction.

Secondary Battery: See "Accumulator".

Secondary Current: A current in which the electromotive force is generated by induction from a primary circuit in which a variable current is flowing. The high-tension current of a jump-spark ignition system.

Secondary Circuit: The circuit which carries high-tension current.

Secondary Spark Coil: An induction coil having a double winding upon its core. The inner winding is composed of a few layers of insulated wire of large size, and the outer winding consists of a great many layers of very small insulated copper wire. Also known as a *jump-spark coil*.

Seize: Refers to moving parts which adhere because of operation without a film of oil between the working surfaces.

Selective Change-Speed Gears: Change-speed gears so arranged that any desired speed combination can be obtained without going through the intermediate steps.

Self-Firing: Ignition of the mixture in a gas engine due to the walls of the cylinder or particles attached to them becoming overheated and incandescent.

Self-Starter: See "Engine Starter".

Separator, Steam: A device attached to steam pipes to separate entrained water from live steam before it enters the engine, or to separate the oily particles from exhaust steam on its way to the condenser.

Series Circuit: A compound circuit in which the separate sources or the separate electrical receiving devices, or both, are so placed that the current supplied by each, or passed through each, passes successively through the other circuits from the first to the last.

Set Screw: A small screw with a pointed end used for locking a part in a fixed position to prevent it from turning.

Setting Valves: See "Valve Setting".

Shaft, Intermediate: The shaft placed between the first and third motion gearing and acting as a carrier of motion between the two.

Shaft Drive: System of power transmission by means of a shaft.

Shim: See "Liner".

Shock Absorber: A device attached to the springs or hangers of motor cars to decrease the jars due to rough roads, instead of allowing them to be transmitted to the frame of the carriage.

Short Circuit: A shunt or by-path of comparatively small resistance around a portion of an electric circuit, by which enough current passes through the new path to virtually cut out the part of the circuit around which it is passed, and prevent it from receiving any appreciable current.

Sight Feed: An indicator covered with glass which shows that oil is flowing in a system. A telltale sight. A check on the oiling system.

Side-Bar Steering: See "Steering, Side-Bar".

Side-Slipping: See "Skidding".

Silencer: See "Muffler, Exhaust".

Silent Chain: A form of driving chain in which the links are comprised of sections which so move over the sprocket that practically all noise is eliminated. Silent chains are used specially for driving timing gears, gearsets, etc.

Skidding: The tendency of the rear wheels to slide sideways to the direction of travel, owing to the slight adhesion between tires and the surface of the roadbed, also called *side-slipping*.

Skip: See "Miss".

Sleeve Valve: A form of valve consisting of cylindrical shells moving up and down in the cylinders of such a motor as the Silent Knight.

Sliding Gears: A change-speed set in which various gears are placed into mesh by the sliding on a shaft of one or more gears.

Sliding Sleeve: See "Motor, Sleeve-Valve".

Slip Cover: A fabric covering for the top when down or for the upholstery of a motor vehicle.

Smoke in Exhaust: Smoky appearance in the exhaust due to too much oil, too rich mixture, low grade of fuel, or faulty ignition.

Solid Tire: See "Tire, Solid".

Sooting of Spark Plug: Fouling of the spark plug with soot, due to poor mixture, impure fuel, or improper lubrication.

Spare Wheel: An extra wheel complete with inflated tire, carried on the car for quick replacement of wheel with damaged tire.

Spark, Advancing: See "Advanced Ignition".

Spark Coil: A coil or coils of wire for producing a spark at the spark plug. It may be either a secondary or primary spark coil.

Spark Gap: A break in the circuit of a jump-spark ignition system for producing a spark within the cylinder to ignite the charge. The spark gap is at the end of a small plug called the *spark plug*.

Spark Gap, Extra: See "Spark Gap, Outside".

Spark Gap, Outside: A device to overcome the short circuiting in the spark gap due to fouling and carbon deposits between the points of the high-tension spark plug. It is a form of condenser, or capacity in which the air acts as the dielectric between two surfaces at the terminals of a gap in a high-tension circuit.

Spark Intensifier: See "Spark Gap, Outside".

Spark Lever: See "Timing Lever".

Spark Plug: The terminals of the secondary circuit of a jump-spark ignition system mounted to leave a spark gap between the terminals projecting inside the cylinder for the purpose of igniting the fuel in the cylinder by means of a spark crossing the gap between them.

Spark Plug, Pocketing: Mounting the spark plug in a recess of the cylinder head to reduce the sooting of the sparking points.

Spark Plug, Sooting of: See "Sooting of Spark Plug".

Spark Regulator: A mechanism by which the time of ignition of the charge is varied by a small handle on or near the steering wheel.

Spark, Retarding: See "Ignition, Retarding".

Spark Timer: See "Timer, Ignition".

Speaking Tube: See "Annunciator".

Specific Gravity: The weight of a given substance relative to that of an equal bulk of some other substance which is taken as a standard of comparison. Air or hydrogen is the standard for gases, and water is the standard for liquids and solids.

Specific Heat: The capacity of a substance for removing heat as compared with that of another which is taken as a standard. The standard is generally water.

Speed-Change Gear: A device whereby the speed ratio of the engine and driving wheels of the car is varied.

Speed Indicator: An instrument for showing the velocity of the car.

Speedometer: A device used on motor cars for recording the miles traveled and for indicating the speed at all times.

Speedometer Gears: Gears used to drive a shaft which operates the speedometer.

Speedometer Shaft: A flexible shaft which operates a speedometer.

Spiral Gear: A gear with helically-cut teeth.

Splash Lubrication: See "Lubrication, Splash".

Spline: A key.

Spontaneous Ignition: See "Self-Firing".

Sprag: A device to be let down (usually at the rear of the car) to prevent its slipping back when climbing a hill.

Spray Nozzle: That portion of a carbureter which sprays the gasoline.

Spring: An elastic body, as a steel rod, plate, or coil, used to receive and impart power, regulate motion, or diminish concussion.

Spring, Cantilever: A type of spring which appears like a semi-elliptic reversed; and which is flexibly attached in the center, rigidly at one end, and by a shackle at the other.

Spring, Elliptic: A spring, elliptic in shape, and consisting of two half-elliptic members attached together.

Spring Semi-Elliptic: A spring made up of a number of leaves, the whole resembling a portion of an ellipse.

Spring, Supplementary: See "Shock Absorber".

Spring, Underslung: A spring which is fastened under the axle instead of over it.

Spring Hangers: See "Body Hangers".

Spring Shackle: A link attached to one end of a spring which allows for flattening of the spring.

Sprocket: A wheel with teeth around the circumference, so shaped that the teeth will fit into the links of a chain which drives or is driven by the sprocket.

Starboard: The right-hand side of a ship or vessel.

Starter, Engine: See "Engine Starter".

Starting, Gas Engine: The operation necessary to make the engine automatically continue its cycle of events. It usually consists of opening the throttle, retarding the spark, closing the ignition circuit, and cranking the engine.

Starting Crank: A crank by which the engine may be given several revolutions by hand in order to start it.

Starting Device: See "Engine Starter".

Starting on Spark: In engines having four or more cylinders with well-fitting pistons, it is often possible to start the motor after it has stood idle for some time by simply closing the ignition circuit, provided that the previous stopping of the engine was done by opening the ignition circuit before the throttle was closed, leaving an unexploded charge under compression in one of the cylinders.

Steam: The vapor of water; the hot invisible vapor given off by water at its boiling point.

Steam Boiler: See "Boiler".

Steam Condenser: See "Condenser".

Steam, Cycle of: A series of operations of steam forming a closed circuit, a fresh series beginning where another ends; that is, steam is generated in the boilers, passes through the pipes of the engine, doing work successively in its various cylinders, escaping at exhaust pressure to the condenser, where it is converted into water and returned to the boiler, to go through the same operations once more.

Steam Engine: A motor depending for its operation on the latent energy in steam.

Steam Gage: See "Pressure Gage".

Steam Port: See "Admission".

Steering, Side-Bar: Method of guiding the car by means of an upright bar at the side of the seat.

Steering Angle for Front Wheels: Maximum angle of front wheels to the axle when making a turn; should be about 35°.

Steering Check: A device for locking the steering gear so that the direction will not be changed unless desired.

Steering Column: See "Steering Post".

Steering Gear: The mechanism by which motion is communicated to the front axle of the vehicle, by which the wheels may be turned to guide the car as desired.

Steering Knuckle: A knuckle connecting the steering rods with the front axle of the motor.

Steering Lever: A lever or handle by which the car is guided.

Steering Neck: The vertical spindle carried by the steering yoke. It is the pivot of the bell crank by which the wheel is turned.

Steering Pillar: See "Steering Post".

Steering Post: The member through which the twist of the steering wheel is transmitted to the steering knuckle. The steering post often carries the spark and throttle levers also.

Steering Rod: The rod which connects the steering gear with the bell cranks or pivot arms, by means of which the motor car is guided.

Steering Wheel: The wheel by which the driver of a motor car guides it.

Steering Yoke: The Y-shaped piece in which the front axle terminates. The yoke carries the vertical steering spindle or steering neck.

Stephenson Link Motion: A reversing gear in which the ends of the two eccentric rods are connected by a link or quadrant sliding over a block at the end of the valve spindle.

Step-Up Coil: A coil used to transform low- into high-tension current.

Storage Battery: See "Accumulator".

Stroke: See "Piston Stroke".

Strainer, Gasoline: A wire netting for preventing impurities entering the gasoline feed system.

Strangle Tube: The narrowing of the throat of the carbureter just above the air inlets in order to increase the speed of the air, and thus increase the proportion of gas which will be picked up.

Stroke: The distance of travel of a piston from its point of farthest travel at one end of the cylinder to its point of farthest travel at the other end. Two strokes of the piston take place to every revolution of the crankshaft.

Stud Plate: The plate or frame in a planetary transmission system carrying studs upon which the central pinions revolve.

Suction Valve: The type of admission valve on an internal combustion engine which is opened by the suction of the piston within the cylinder and admits the mixture. The valve is normally held to its seat by a spring.

Sulphating of Battery: The formation of an inactive coating of lead sulphate on the surface of the plates of a storage battery. It is a source of loss in the battery.

Superheated Steam: Steam which has been still further heated after reaching the point of saturation.

Supplementary Air Valve: See "Auxiliary Air Valve".

Swivel Joint: The joint for connecting the steering arm of the wheel or lever-steering mechanism to the arms on the steering wheel. Also called *knuckle joint.*

T

Tachometer: An instrument for indicating the number of revolutions made by a machine in a unit of time.

Tandem Engine: A compound engine having two or more cylinders in a line, one behind the other, and with pistons attached to the same piston rod.

Tank Gage: See "Fuel-Level Indicator".

Tappet Rod: See "Push Rod".

Taxicab: A public motor-driven vehicle in which the fare is automatically registered by the taximeter.

Taximeter: An instrument in a public vehicle for mechanically indicating the fare charged.

Terminals: The connecting posts of electrical devices, as batteries or coils.

Thermal Unit: Usually called the *British Thermal Unit,* or *B. t. u.* A measure of mechanical work equal to the energy required to raise one pound of water one degree Fahrenheit.

Thermostat: An instrument to automatically regulate the temperature.

Thermosiphon Cooling: A method of cooling the cylinder of a gas engine. The water rises from the jackets and siphons into a radiator from whence it returns to the supply tank, doing away with the necessity for a circulating pump.

Three-Point Suspension: A method used for suspending motor car units, such as the motor, on three points.

Throttle: A valve placed in the admission pipe between the carbureter and the admission valve of the motor to control the speed and power of the motor by varying the supply of the mixture.

Throttle, Foot: See "Accelerator".

Throttle, Lever: A lever on the steering wheel which operates the carbureter throttle. See "Throttle".

Throttling: The act of closing the admission pipe of the engine so that the gas or steam is admitted to the cylinder less readily, thus cutting down the speed and power of the engine.

Thrust Bearing: A bearing which takes loads parallel with the axis of rotation of the shaft upon which it is fitted.

Tickler: A pin in a carbureter arranged to hold down the float in priming, also called *flushing pin* and *primer.*

Timer, Ignition: An ignition commutator.

Timing Gears: The gears which operate the camshaft and magneto shaft. The camshaft gear is twice as large as the crankshaft gear.

Timing Lever: A lever fitted to gas engines by means of which the time of ignition is changed. Also called *spark lever.*

Timing Valve: In a gas engine using float-tube ignition, a valve controlling the opening between the combustion space and the igniter.

Tip, Burner: A small earthen, aluminum, or platinum cover for the end of the burner tube of an acetylene lamp. It is usually provided with two holes, so placed that the jets from them meet and spread out in a fan shape.

Tire, Airless: See "Airless Tire".

Tire, Clincher: A type of pneumatic tire which is held to a clincher.

Tire, Cushion: Vehicle tire having a very thick rubber casing and very small air space. It is non-puncturable and does not have to be inflated, but is not as resilient as a pneumatic tire.

Tire, Non-Deflatable: See "Tire, Non-Puncturable".

Tire, Non Puncturable: A tire so constructed that it cannot be easily punctured or will not become deflated when punctured.

Tire, Punctures in: Holes or leaks in pneumatic tires caused by foreign substances penetrating the inner tube and allowing the air to escape.

Tire, Single-Tube: A pneumatic tire in which the inner and outer tubes are combined.

Tire, Solid: A tire made of solid, or nearly solid rubber.

Tire Band: A band to protect or repair a damaged pneumatic tire. See "Tire Protector".

Tire Bead: Lower edges of a pneumatic tire which grip the curved portion of a rim.

Tire Case: (1) A leather or metal case for carrying spare tire; same as *tire holder*. (2) The outer tube.

Tire Chain: See "Anti-Skid Device".

Tire Filling: Material to be introduced into the tire to take the place of air and do away with puncture troubles

Tire Gage: Gage used for measuring the air pressure in a pneumatic tire.

Tire Holder: A metal or leather case for carrying spare tires.

Tire-Inflating Tank: A tank containing compressed air or gas for inflating the tires.

Tire Inflater, Mechanical: A small mechanical pump for inflating pneumatic tires.

Tire Patch: See "Patch, Tire Repair".

Tire-Pressure Gage: A pressure gage to indicate the pressure of air in the tire.

Tire Protector: The sleeve or band placed over a tire to protect it from road wear.

Tire Pump: A pump for furnishing air under pressure to the tire, may be either hand- or power-operated.

Tire Sleeve: A sleeve to protect the injured part of a pneumatic tire. It is a tire protector which covers more of the circumference of the wheel than a tire band. See "Tire Protector".

Tire Tape: Adhesive tape used to bind the outer tube to the rim in repairing tires.

Tire Tool: Tool used to apply and remove a tire.

Tire Valve: A small valve in the inner tube to allow air to be pumped into the tube without permitting it to escape.

Tires, Creeping of: See "Creeping of Tires".

Tonneau: The rear seats of a motor car. Literally, the word means a round tank or water barrel.

Torque: Turning effort, or twisting effort of a rotating part.

Torque Rod: A rod attached at one end to the rear axle and at the other to the frame; used to prevent twisting of the rear-axle housing.

Torsion Rod: The shaft that transmits the turning impulse from the change gears to the rear axle. Usually spoken of as the *shaft.*

Touch Spark: See "Wipe Spark".

Tourabout: A light type of touring car.

Touring Car: A car with no removable rear seats, and a carrying capacity of four to seven persons.

Town Car: A car having the rear seats enclosed but the driver exposed.

Traction: The act of drawing or state of being drawn. The pull (or push) of wheels.

Tractor: A self propelled vehicle for hauling other vehicles or implements; a traction engine.

Transmission, Individual Clutch: A transmission consisting of a set of spur gears on parallel shafts which are always in mesh, different trains being picked up with a separate clutch for each set.

Transmission, Planetary: A transmission system in which a number of pinions revolve about a central pinion in a manner similar to the revolution of the planets about the sun; usual type consists of a central pinion surrounded by three or more pinions and an internal gear.

Transmission, Sliding Gear: A transmission system in which sliding change-speed gears are used.

Transmission Brake: Brake operating on the gearset shaft or end of the propeller shaft.

Transmission Gears: A set of gears by which power is transmitted. In automobiles, usually called *change-speed gears.*

Transmission Ratio: The ratio of the speed of the crankshaft to the speed of the transmission shaft or driving shaft.

Tread: That part of a wheel which comes in contact with the road.

Tread, Detachable: A tire covering to protect the outer tube, which may be taken off or replaced.

Trembler: The vibrating spring actuated by the induction coil magnet which rapidly connects and disconnects the primary circuit in connection with jump-spark ignition.

Truck: (1) A strong, comparatively slow-speed vehicle, designed for transporting heavy loads. (2) A swiveling carriage having small wheels, which may be placed under the wheels of a car.

Try Cock: A faucet or valve which may be opened by hand to ascertain the height of water in the boiler.

Tube Case: See "Tire Case".

Tube Ignition: See "Hot-Tube Ignition".

Tubing, Flexible: See "Flexible Tubing".

Tubular Radiator: An automobile radiator in which the jacket water circulates in a series of tubes.

Tungsten Lamp: Incandescent bulb with the filament made of tungsten wire.

Turning Moment: See "Torque".

Turning Radius: The radius of a circle which the wheels of a car describe in making its shortest turn.

Turntable: Device installed in the floor of a garage and used for turning motor cars around.

Two-Cycle or Two-Stroke Cycle Engine: An internal-combustion engine in which an impulse occurs at the beginning of every revolution, that is, at the beginning of every downward stroke of the piston.

Two-to-One Gear: The system of gearing in a four-cycle gas engine for driving the camshaft, which must revolve once to every two revolutions of the crankshaft.

U

Under Frame: The main frame of the chassis or running gear of a motor vehicle.

Unit-Power Plant: A power system consisting of a motor, gearset, and clutch which may be removed from the motor car as a unit.

Universal Joint: A mechanism for endwise connection of two shafts so that rotary motion may be transmitted when one shaft is at an angle with the other. Also called *universal coupling, flexible coupling, Cardan joint* and *Hooke's joint.*

Upkeep: The expenditure for maintenance or expenditure required to keep a vehicle in good condition and repair.

Vacuum Fuel Feed: A system of feeding the gasoline from a tank at the rear of an automobile by maintaining a partial vacuum at some point in the system, usually at the dash, the fuel flowing from this point by gravity to the carbureter.

Vacuum Line: In an indicator diagram, the line of absolute vacuum. It is at a distance corresponding to 14.7 pounds below the atmospheric line.

Valve: A device in a passage by which the flow of liquids or gases may be permitted or stopped.

Valve, Admission: The valve in the admission pipe of the engine leading from the carbureter to the cylinder by which the supply of fuel may be cut off.

Valve, Automatic: See "Automatic Valve".

Valve, Inlet: See "Inlet Valve".

Valve, Mixing: See "Mixing Valve".

Valve, Muffler Cut-Out: See "Cut-Out, Muffler".

Valve, Overhead: See "Overhead Valve".

Valve, Poppet: See "Poppet Valve".

Valve, Rotary: See "Motor, Rotary Valve".

Valve, Suction: An admission valve which is opened by the difference between the pressures in the atmosphere and in the cylinder.

Valve Cage: A valve-retaining pocket which is attached to the cylinder.

Valve Clearance: The clearance of play between the valve stem and the tappet.

Valve Gear: The mechanism by which the motion of the admission or exhaust valve is controlled.

Valve Grinding: The act of removing marks of corrosion, pitting, etc., from the seats and faces of poppet or disk valves. The surfaces to be ground are rotated in contact with each other, an abrasive having been supplied.

Valve Lift: See "Lift".

Valve Lifter: A device for raising a poppet valve from its seat.

Valve Seat: (1) That portion of the engine upon which the valve rests when it is closed. (2) The portion upon which the face of a valve is in contact when closed.

Valve Setting: The operation of adjusting the valves of an engine so that the events of the cycle occur at the proper time. Also called *valve timing.*

Valve Spring: The spring which is around the valve stem and is used to return the valve to closed position after it has been opened by the cam:

Valve Stem: The rod-like portion of a poppet valve.

Valve Timing: See "Valve Setting".

Vaporizer: A device to vaporize the fuel for an oil engine. In starting it is necessary to heat the vaporizer, but the exhaust gases afterwards keep it at the proper temperature. The carbureter of the gas engine properly belongs under the general head of *vaporizer*, but the term has become restricted to the vaporizer for oil engines.

Variable-Speed Device: See "Gear, Change-Speed".

Vertical Motor: An upright engine whose piston travel is in a vertical plane.

Vibrator: The part of the primary circuit of a jump-spark ignition system by which the circuit is rapidly interrupted to give a transformer effect in the coil.

Vibrator, Master: See "Master Vibrator".

Volatile: Passing easily from a liquid to a gaseous state, in opposition to *fixed.*

Volatilization: Evaporation of liquids upon exposure to the air at ordinary temperatures.

Volt: Practical unit of electromotive force; such an electromotive force as would cause a current of one ampere to flow through a resistance of one ohm.

Voltammeter: A voltmeter and an ammeter combined; sometimes refers to wattmeter.

Voltmeter: An instrument for measuring the difference of electric potential between the terminals of an electric circuit. It registers the electric pressure in volts.

Vulcanization: The operation of combining sulphur with rubber at a high temperature, either to make it soft, pliable, and elastic, or to harden it.

Vulcanizer: A furnace for the vulcanization of rubber.

W

Walking Beam: See "Rocker Arm".

Water Cooling: Method of removing the heat of an internal-combustion motor from the cylinders by means of a circulation of water between the cylinders and the outer casing.

Water Gage: An instrument used to indicate the height of water within a boiler or other water system. It consists of a glass tube connected at its upper and lower ends with the water system.

Water Jacket: A casing placed about the cylinder of an internal-combustion engine to permit a current of water to flow around it for cooling purposes.

Watt: The unit of electric power. It is the product of the current in amperes flowing in a circuit by the pressure in volts. It is $\frac{1}{746}$ of a horsepower.

Watt Hour: The unit of electrical energy. The given watt-hour capacity of a battery, for instance, means the ability of a battery to furnish one watt for the given number of hours or the given number of watts for one hour, or a number of watts for a number of hours such that their product will be the given watt hours.

Welding, Autogeneous: A method of joining two pieces of metal by melting by means of a

blow torch burning acetylene in an atmosphere of oxygen. This melts the ends of the parts and these are then run together.

Wheel, Artillery: A wood-spoked wheel whose spokes are in line with a line drawn vertically through the hub.

Wheel, Dished: A wheel made concave or convex so that the hub is inside or outside as compared with the rim. This is to counteract the outward inclination of the wheel due to the fact that the spindle is tapered and that its outward center is lower than its inner center.

Wheel, Double-Interacting: The mechanism by which two wheels are hung on one hub or axle, the outer being shod with an ordinary solid tire and the inner with a pneumatic tire, so that the weight of the vehicle bears against the lowest point of the pneumatic tire of the inner wheel to give the durability and tractive properties of a solid tire with the resiliency of a pneumatic.

Wheel, Spare: See "Spare Wheel".

Wheel Steering: See "Steering Wheel".

Wheel, Wire: A wheel with spokes made of wire.

Wheel Puller: A device used for pulling automobile wheels from their axles.

Wheel Steer: A method of guiding a car by means of a hand wheel.

Wheel, Steering Angle for: The angle which the steering column makes with the horizontal. It varies from 90° to 30° or less.

Wheelbase: The distance between the road contact of one rear wheel with the point of road contact of the front wheel on the same side.

Wheels, Driving on All Four: The method of using all four wheels of an automobile as the driving wheels.

Wheels, Driving on Front: The method of using the two front wheels as the drivers.

Wheels, Steering on Rear: Method of guiding the vehicle by turning the rear wheels.

Whistle: An automobile accessory consisting of a signalling apparatus giving a loud or harsh sound. Also called a *horn*.

Wind Guard: See "Wind Shield".

Wind Shield: A glass front placed upright on the dash to protect the occupants of the car from the wind.

Wipe Spark: Form of primary sparking device in which a spark is produced by a moving terminal sliding over another terminal, the break thus made causing a spark. Also called *touch spark*.

Wipe-Spark Coil: A primary spark coil with which the spark is made by wiping contact.

Wire Drawing: The effect of steam passing through a partially closed valve or other constricted opening; so called from the thinness of the indicator diagram.

Working Pressure: The safe working pressure of a boiler, usually estimated as $\frac{1}{6}$ of the pressure at which a boiler will burst.

Worm: A helical screw thread.

Worm and Sector: A worm gear in which the worm wheel is not complete but is only a sector. Used especially in steering devices.

Worm Drive: A form of drive using worm gears. See "Gears, Worm".

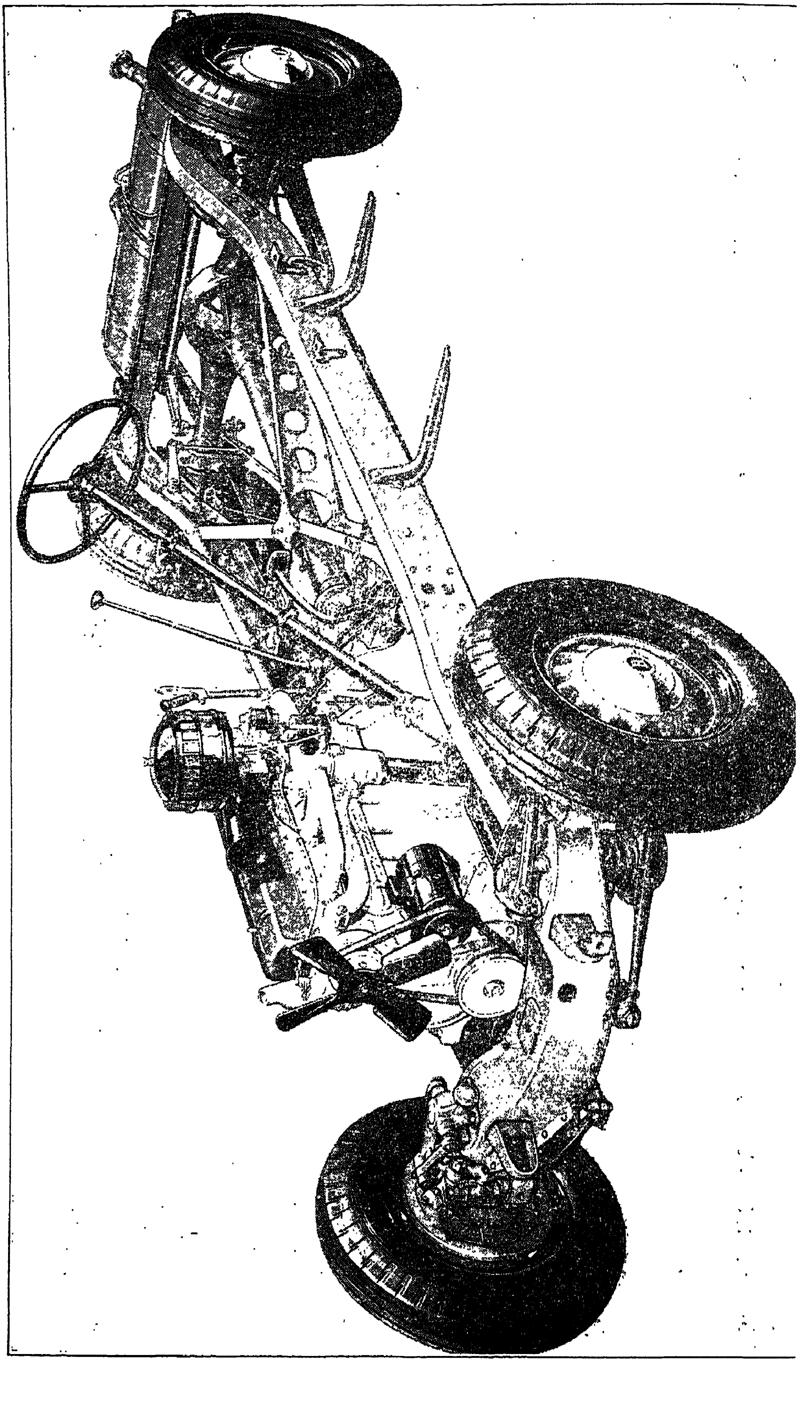
Worm Gear: The spiral gear in which a worm or screw is used to rotate a wheel

Worm Wheel: A wheel rotated by a worm.

Wrist Pin: See "Piston Pin".

X Spring: A vehicle spring composed of two laminated springs so placed one upon the other that they form the letter X.

Yoke, Steering: See "Steering Yoke"



Index